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# BILATERAL UVEITIS WITH ASSOCIATED DETACHMENT OF THE RETINA

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In a former article in the ARCHIVES [1] I reported 2 cases of Harada's disease, bilateral uveitis associated with detachment of the retina. In the second case the uveitis was less severe and in the early stage examination, even with the slit lamp, failed to reveal keratitic deposits. The detachment healed spontaneously, the hypotonia disappeared and within three months normal vision of one eye and almost normal vision of the other eye was restored. The fundus picture of each eye after completion of the healing process was shown.

The extreme severity of the uveitis in the first case was pointed out. The uveitis was instrumental in the development of a complicated cataract in each eye, which in turn precluded inspection of the deeper parts of the eye. In November 1939, about two years after the ocular disease had first manifested itself, the cataract was removed from the left eye. Operative intervention and healing were uneventful; the eye responded surprisingly well and without inflammatory reaction to the operative trauma.

The cataract having been removed, the eyeground revealed the changes shown in the accompanying illustration. The margins of the disk appear absolutely sharp and well defined. Along the nasal border a narrow interrupted pigment line is visible. In the upper and lower parts of the periphery the fundus appears white and there is a well defined albinotic picture, with visible choroidal vessels of various calibers and directions. Areas poor in or completely free of pigment are extensive and merge without sharp demarcation into parts that have normal pigmentation. In the upper temporal part there are numerous small white patches in close proximity. These are oval and increase in size as they approach the periphery. The spaces between the patches appear normal. A few of the patches near the disk show delicate

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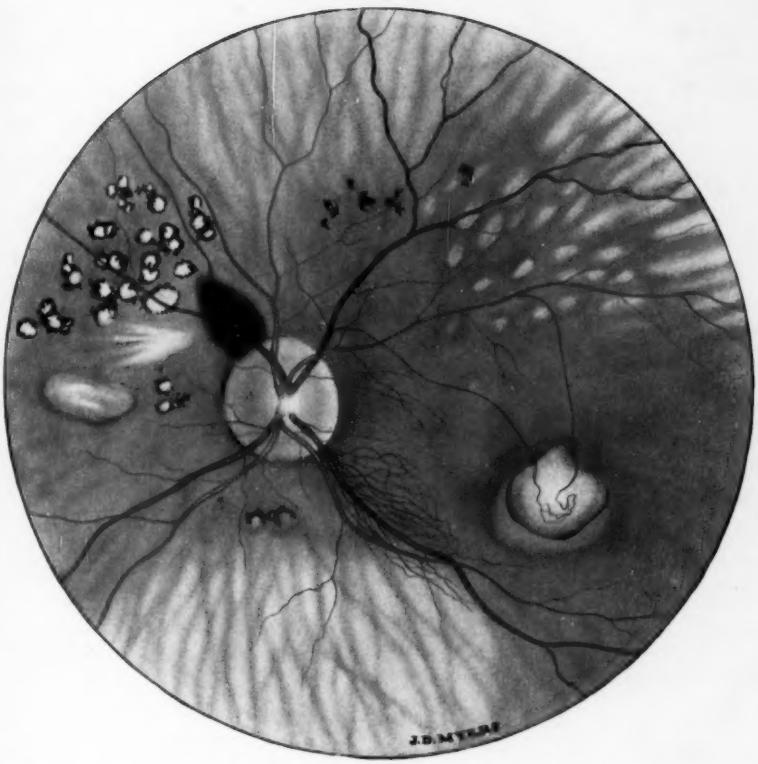
1. Rados, A.: Bilateral Uveitis Associated with Detachment of Retina (Harada's Disease), Arch. Ophth. **23**:534 (March) 1940.

grayish black pigmentation. The outlines of the individual patches are rather sharp. The retinal vessels over the patches manifest no pathologic change and no differences in the niveau. In the center of the disk, white tissue veils the vessels. Along the course of the macular artery and vein in the lower temporal quadrant, adjoining the disk, a net of delicate, newly formed capillaries is visible. In the upper nasal quadrant, adjoining the margin of the disk, a tongue-shaped black pigment patch, sharply outlined from the adjacent normal area, is seen. Temporally and upward, in the periphery, the entire region is filled out by small, sharply outlined, snow white atrophic choroidal patches with a black pigment border. Some of the patches are in groups of two or three and show a tendency to coalesce. Nasally and downward from the disk, similar small patches can be noted; upward from the disk, on the other hand, small pigment patches without atrophic changes in the choroid are present. In the nasal part a white connective tissue patch with a fanlike opening toward the periphery merges into the normal tissues. In the direction of 9 o'clock, almost 1 disk diameter from the nasal margin of the disk, a large horizontally oval grayish white patch, with sharp outlines and some bulging, is seen; around the lower outline of the patch delicate pigmentation is observed.

In the macular region an almost disk-sized patch—the horizontal diameter being the longest—with a slight protrusion upward is noted; this patch appears almost round, bulges and has its upper pole somewhat below the foveolar area. The patch is white in the center and becomes increasingly grayish toward the periphery. At the lower margin of the patch yellowish choroidal atrophic areas, half-moon shaped, are present near the normal areas. One branch of the superior macular artery and vein are seen within the patch, the course of the vessels outlining the bulging of the patch.

The extremely severe pathologic condition of the eyeground in this case is in distinct contrast to the changes in my second case. I shall recapitulate briefly my previous description: A pale, somewhat yellowish color of the fundi, rather than the usual red, was characteristic. Both fundi, especially in the macular region, exhibited numerous small patches of pigment which were brownish, in contradistinction to the black usually found in the pigment frame and the overpigmentation of atrophic patches in old choroidal lesions. Most of the patches were located in the macular region and only a few in the periphery. The patches were round or oval, small and without sharp margins. In each eyeground one pigmented stripe was visible; in the course of the stripe the retinal vessels were both underbridged and overbridged, which denoted that the stripe was located in different layers of the retina.



The left fundus after removal of a cataract which had developed as a sequel to Harada's disease.

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The severity of the clinical picture in the first case was carefully stressed and contrasted with the relatively mild course in the second case. The difference between the ophthalmoscopic picture and the severity of the uveal involvement is stressed in the present paper.

Since the appearance of my paper, Magitot and Dubois-Poulsen [2] have published 3 interesting and somewhat similar cases. In their first case a woman 28 years of age had complained chiefly of frontal headaches and vomiting; she was delirious and irresponsive to questioning when examined. The eyes were red. There were no depositis and no synechias. Fibrinous exudation was present at the anterior surface of the lens. The pupillary reaction was good. The intraocular pressure was not increased. The fundi were invisible. General and neurologic examinations revealed no abnormality. The Wassermann reaction was negative. The teeth and tonsils were normal. One week later the fundi were visible in spite of an intense pathologic process in the vitreous. There was greenish detachment of the retina in the lower part of the right eye and in the temporal region of the left eye; the disks were red and surrounded by a thick and cloudy area. After eight days the general condition became worse. The patient suffered from excruciating headaches and was delirious. The lack of general symptoms suggested tuberculous meningitis. The clinical picture remained unchanged for one month, with slight fever persisting. Toward the fifteenth week there was a gradual improvement in the cerebral symptoms. The patient began to utter words, but hearing was absent. The vitreous was clearer, the detachment persisting in the inferior part. The detachment disappeared in the fourth month, being replaced through extensive chorioretinal scars by edematous white patches with pigment frames. The hearing was good; the vision was 1/10; there was no vitiligo and no involvement of the hair. Seven months after the onset of the disease the vision had improved to 2/10. The disks were pale gray, and retinal hemorrhages were present in the left eye.

In their second case a man 53 years of age had a sudden onset, with loss of consciousness; later there were headaches and loss of vision. In the second month of the disease edema of the disk and retinal hemorrhages were noted. Later the patient was almost blind. The fundi were invisible. The pupillary reaction was good. There was paralysis of the sixth nerve on the right. In the sixth month there was bilateral uveitis with symmetric grayish green detachments in the lower part. The corneas and the anterior chambers were normal; there were no synechias. General examination revealed no abnormality; there was no fever. The Wassermann reaction was negative. The blood pressure was 115 systolic and 70 diastolic. Examination one year later

2. Magitot, A., and Dubois-Poulsen: Ann. d'ocul. **177**:145, 1940.

revealed a gray, partly atrophic disk in the left eye, vitreous floaters and in the lower part of the fundus, at the site of the former detachment, light gray patches resembling retinitis proliferans, with remnants of bleedings. The right eye had vision of 3/10. The fundus was invisible, but in the lower part, at the site of the detachment, a light patch was distinguishable. There was no vitiligo. There was no pathologic change in the hair.

In their third case a woman 39 years of age had a sudden onset, with pain, redness of the conjunctiva and photophobia. In the next twenty-four hours the pain was more intense and chemosis appeared. Headaches and bilateral uveitis followed. General examination gave negative results. There were extensive posterior synechias. Three weeks later anterior uveitis developed; the corneas became hazy; there were some deposits; the iris was dull; the vitreous was cloudy; the fundi were almost invisible, and the retinal vessels were dilated. A few days later the hair on the temples turned white; the lashes remained normal. A bilateral detachment of the retina in the lower part was suspected because of the grayish aspect of the lower part of the pupillary area, but the haziness of the cornea prevented inspection of the fundi, thus making an accurate diagnosis impossible. In a few days vision improved, the vitreous cleared and there was no visible detachment. After several months the right fundus exhibited only mild myopic choroiditis; the left was normal. The graying of the hair on the temples had progressed.

The authors classified their cases as instances of Harada's disease and enumerated as typical and general symptoms, headaches, slight fever, bilateral anterior or posterior uveitis, retinal bleedings, redness of the disks, congestion and dilatation of the veins and the presence of opacities in the vitreous which often obstructed inspection of the fundus. Scleritis, occasionally present (Urbanek, Pichler, Igersheimer), was considered as part of the same group of symptoms. They drew the conclusion that various degrees of auditory disturbances or deafness (Parker, Rones, Harada, Koyanagi), loss of hair, baldness, turning of the hair and lashes grayish or white and vitiligo of the neck, shoulders and extremities are symptoms to be found in the majority of cases in which uveitis is associated with a detachment of the retina that heals spontaneously, with good functional recovery. The case of Dejean and Viallefont, in the French literature, was cited as of this type. So also the case of Schiff-Wertheimer, in which a child 5½ years of age had right hemiparesis and blindness of the right eye due to severe iridocyclitis, with extensive chorioretinal lesions and temporal detachment of the retina, and an apparently normal left eye.

Before analyzing the symptoms in detail, I want to emphasize the fact that in the first and second cases reported by Magitot and Dubois-

Poulsen bilateral uveitis accompanied by general symptoms caused bilateral retinal detachment but neither vitiligo nor poliosis was present. Only in the third case was the graying of the hair in the temporal region noted, and in this case the detachment was only suspected, haziness of the vitreous precluding examination of the retina, so that an accurate diagnosis was rendered impossible. After complete recovery the left fundus was normal and the right exhibited only slight myopic choroiditis, findings totally at variance with the changes usually encountered after spontaneous healing of the retinal detachment associated with bilateral uveitis.

Reviews of this disease and closely related diseases of the eye usually refer to Vogt [3] as having made the first case report. Davis [4] cited the article by Koyanagi,[5] who in 1929 reviewed statistically 10 previously reported cases and added 6 observed by himself. The association of poliosis with an inflammatory change in the eyes, namely sympathetic ophthalmia, was first noted, in 1873, by Schenkel and subsequently reported by Jacobi, Nettleship, Bock and Tay. Hutchinson [6] was the pioneer in the description of poliosis of both upper lids associated with a form of bilateral iridocyclitis that resulted in total loss of vision. These observations are mentioned only to show that the connection between poliosis and ocular disease was clearly recognized. Poliosis had previously been attributed to nervous influences, often fright, and classified as poliosis neurotica. Graying of the hair in the course of trigeminal neuralgia, functional neuroses and migraine (Lotin), or without known cause, was frequently reported, for example by Rindfleisch, Hirschberg and de Schweinitz. In the case reported by Vogt, three months after the onset of severe iridocyclitis in an 18 year old youth, poliosis of both upper lids developed and was accepted as a sequel to the iridocyclitis. Other complications, such as deafness or alopecia, were not mentioned.

In his statistical review Koyanagi, also, listed Vogt's case as the first, overlooking cases of poliosis in association with sympathetic ophthalmia and the case of Hutchinson in which poliosis was associated with bilateral iridocyclitis. Similarly, he did not mention the case of Erdman,[7] in which hemeralopia persisted for six months in a 44 year old man with no objective abnormalities. In the course of the disease, chorioretinitis with marked exudation into the vitreous developed; the cornea and the iris remained free of pathologic change. In the

3. Vogt, A.: Klin. Monatsbl. f. Augenh. **44**:242, 1906.

4. Davis, W. S.: Uveitis with Associated Alopecia and Poliosis, Arch. Ophth. **14**:239 (Aug.) 1935.

5. Koyanagi, Y.: Klin. Monatsbl. f. Augenh. **82**:194, 1929.

6. Hutchinson, N.: Arch. Surg., London **4**:357, 1892-1893.

7. Erdman, P.: Klin. Monatsbl. f. Augenh. **49**:129, 1911.

periphery of the fundi, round patches of exudate measuring ½ disk diameter were observed. Later, marked depigmentation led to an almost albinotic appearance of the fundi around the disks. Numerous atrophic patches in the periphery, with occasional confluence into larger ones, were seen. Around the atrophic patches the absence of pigmentation was striking. There was a distinct parallelism between the development and disappearance of the ocular disease and vitiligo. The hair and beard showed areas markedly white, and there was lack of pigmentation of the underlying skin. The left eyebrow appeared white, but the right had only a few white hairs. The vitiligo extended to the cheeks, temporal region of the head, breast, chest, back, pubis, scrotum and penis.

Koyanagi's article [5] was the first extensive review of severe bilateral uveitis associated with dysacousia, alopecia, vitiligo and poliosis. The last survey of the subject, made by Parker,[8] included 29 reported cases (6 cases reported by Japanese authors being omitted because the records could not be checked). The condition is marked by initial general symptoms such as headaches and dizziness, followed by severe uveitis, which usually appears as diffuse choroiditis and develops into severe plastic or serous iridocyclitis. Koyanagi reported that the lens remains transparent, and not even a late complicated cataract is mentioned in the cases cited. The disease is associated with alopecia, vitiligo, poliosis and partial deafness. Alopecia, together with poliosis, is present in all cases; vitiligo was present in 79 per cent and deafness in 72 per cent of Parker's cases. The severity of the clinical picture recalls sympathetic ophthalmia, with which alopecia, vitiligo, poliosis and sympathetic deafness do occur, even if rarely. The infrequency of these symptoms in association with sympathetic ophthalmia must be obvious, because except in the latest reports the lack of general symptoms in cases of sympathetic ophthalmia was generally stressed.

In the course of the uveitis, hypotonia and extreme deepness of the anterior chamber are often encountered. Inspection of the fundus is frequently impossible, but retinal detachment, as far as I am able to determine from a study of the recorded cases, was reported only twice, once by Koyanagi and once by Arisawa.[9] Retinal detachment seems definitely not to belong to the syndrome and appears to be a rare complication when one considers the presence of alopecia and poliosis in all cases and of vitiligo and deafness in the great majority. Since retinal detachment occurred only twice in the entire series of

8. Parker, W. R.: Am. J. Ophth. **14**:577, 1931; Severe Uveitis with Associated Alopecia, Poliosis, Vitiligo and Deafness: Second Review of Published Records, Arch. Ophth. **24**:439 (Sept.) 1940.

9. Arisawa, cited by Koyanagi.[5]

cases, one can hardly avoid questioning whether its presence is only a coincidence, since it is encountered but occasionally in association with sympathetic uveitis or tuberculous choroiditis. Considering the rarity of its appearance in the series of cases reported, it cannot be regarded as an integral part of the syndrome.

The syndrome consists of the bilateral uveitis, of alopecia and poliosis in all cases and of vitiligo and auditory disturbances in the majority of cases. The alopecia is of the variety called alopecia areata, which only rarely affects the region of the eyebrows and the lashes except in the form of alopecia maligna. But when alopecia has been associated with uveitis it has always been accompanied by poliosis. The association of alopecia areata with vitiligo in the dermatologic literature is so infrequent that the occurrence of the latter is considered a mere coincidence. The vitiligo which accompanies bilateral uveitis is more often present in association with alopecia than without the presence of uveitis. The actual causes of both alopecia and vitiligo are unknown.

In summing up the present knowledge of alopecia areata, one may state that in some cases it is explainable on the basis of a trophoneurotic disturbance and in others only on that of an endocrine disturbance. The dystrophic theory—that the disease is precipitated by distant reflexes arising from the teeth, viscera, etc.—is constantly losing adherents; alopecia areata, from the dermatologic standpoint, is only a symptom of various diseases, such as dermatitis exfoliativa resulting from psoriasis, leukemia, eczema, tuberculosis and metallic poisoning. The symptoms of alopecia can be produced by a number of causes, and the transmission of an unknown virus may be one of the factors. The theory that an endocrine disturbance is the cause of alopecia is strengthened by its occurrence with Basedow's disease, vitiligo and nervous disorders.

Cramer,[10] influenced by Peters' explanation of the acoustic disturbances in cases of sympathetic ophthalmia as anaphylactic, tried to explain the canities and poliosis accompanying nontraumatic uveitis on the basis of the anaphylactic theory of Elschnig. According to this theory the injury to the uveal tract produces, through organ-specific antibodies, an anaphylactic reaction. In line with this reasoning, the auditory disturbances accompanying sympathetic ophthalmia are said to be caused by a specific lesion of the pigment present in the labyrinth. Changes in the hair have been similarly explained by sensitization to pigment, with subsequent loss and depigmentation. But, in connection with the anaphylactic explanation, one must note that the presence of organ-specific antibodies of uveal tissue and of pigment, on which the theory of Elschnig so heavily leaned, could not be confirmed in my

10. Cramer, E.: Klin. Monatsbl. f. Augenh. **51**:205, 1913.

experiments [11] or those of von Szily,[12] and therefore the theory itself lacks the proper foundation.

Furthermore, concerning sympathetic deafness, it must be remembered that the labyrinth in animals contains a large amount of pigment, while, on the contrary, the basilar membrane in man is not pigmented. It has been suggested, therefore, that accidental or congenital pigmentation occasionally present in the membrane may undergo changes resulting in partial deafness. Rones [13] employed Wood's intracutaneous uveal pigment test in 3 cases of uveitis and obtained a positive reaction in only 1. In his opinion this would not disprove the theory that the disturbance in pigment is anaphylactic, because when the patients were examined the disease had already passed the acute stage and the allergy may have been diminished. Nevertheless, it is interesting to note that the only case in which the cutaneous pigment test yielded a positive result was also one of rather long-standing uveitis; so diminution in sensitivity could have occurred in it as in the other 2 cases.

Severe bilateral uveitis accompanied by alopecia, poliosis, vitiligo and auditory disturbances is a distinct clinical entity. The severity of the clinical picture suggests sympathetic ophthalmia, but in prognosis and ultimate outcome the two conditions differ greatly. In his second paper, Parker, reviewing 29 cases and adding 2 new ones of his own, emphasized that 30 per cent of the patients recovered vision of 6/12 or better. The constant association of alopecia and poliosis and the relatively frequent occurrence of vitiligo and partial deafness with bilateral uveitis have been thoroughly emphasized. The striking similarity of the syndromes described by the various authors makes their classification as a separate uveal disease easily possible and understandable. Accompanying the syndrome, detachment of the retina may rarely occur. Of all the reported cases, retinal separation was actually observed in only 2 (Koyanagi's second case, and Arisawa's case). Exudation in the anterior segment of the eye is usually so severe that the view of the fundus is fleeting and illusory.

Parker's review did not mention the patient of Jess,[14] a girl 12 years of age with poliosis and vitiligo but without dysacousia, in whom complicated cataract and dystrophia adiposogenitalis developed. Polyglandular disturbance, with hypofunction of the hypophysis, the thyroid gland and the adrenal glands, was noted, and depigmentation of the iris, of the choroid and possibly of the pigment epithelial layer were

11. Rados, A.: Ztschr. f. Immunitätsforsch. u. exper. Therap. **19**:579, 1913.
12. von Szily, A.: Klin. Monatsbl. f. Augenh. **56**:79 and 197, 1916.
13. Rones, B.: Uveitis with Dysacousia, Alopecia and Poliosis, Arch. Ophth. **7**:847 (June) 1932.
14. Jess, A.: Ber. ü. d. Versamml. d. deutsch. ophth. Gesellsch. **49**:469, 1932.

present. Similarly, Krasnoff reported hypofunction of the gonads, of the adrenals and possibly of the posterior lobe of the pituitary. Endocrine involvement is not mentioned in other reports in the literature.

The second type of severe bilateral uveitis, Harada's disease, represents an entity in itself and is marked by its connection with a bilateral retinal detachment with a tendency toward spontaneous healing. In my first paper I reported the relatively mild course and the excellent visual recovery in my second case. In the present paper, the final outcome and the ophthalmoscopic picture after extraction of the cataract in my first case are presented. The extensive changes in the fundi are in distinct contrast to the changes discussed in the previous publication. As a further point of interest, the development of a cataract following uveitis of the Harada type should be mentioned, since with uveitis associated with alopecia and poliosis, there is no formation of cataract (Koyanagi). There seems to be a distinct separation between the two syndromes, and a dualistic viewpoint is justifiable. Only Magitot and Dubois-Poulsen are unitaristic and include in the discussion of their cases designated as instances of Harada's disease cases of bilateral uveitis accompanied by alopecia and poliosis. A careful analysis of the 3 cases presented by these authors reveals the fact that in the first 2 there was retinal detachment without vitiligo or pathologic condition of the hair, while in the third there was canities at the temple but the presence of retinal separation was merely suggested, not definitely established. After completion of the healing process, the right fundus revealed only slight myopic choroiditis; the left was normal. In other words, there was absence of the usual depigmentation and proliferative pigment changes, well known sequels to the spontaneous healing of retinal detachment in the Harada entity and cardinal points in diagnosis.

Ogawa, Sugomito and Kodama differentiated the two syndromes, while Koh and Kotsuki [15] treated them as similar entities. Malbran and Muhlmann [16] expressed the opinion that Harada's disease and the conditions described by Koyanagi are different syndromes which bear some relation to each other.

Bilateral uveitis with retinal detachment (Harada's disease) and bilateral uveitis associated with alopecia, poliosis and, occasionally, vitiligo and partial deafness are severe nontraumatic forms of uveitis, while sympathetic uveitis is the most severe type of traumatic uveitis. Clinically, sympathetic uveitis differs from the first two conditions in that it occurs only after perforating injuries (except in cases of necro-

15. Koh and Kotsuki, cited by Gilbert, W.: Zentralbl. f. d. ges. Ophth. **43**:625, 1939.

16. Malbran, J., and Muhlmann, V.: Cong. argent. de oftal. (1936) **2**:194, 1938.

tizing melanosarcoma). The clinical observation that sympathetic ophthalmia followed nonpenetrating iridocyclitis is not conclusive; histologic study of serial sections would be necessary to prove that a small perforation of the tunica sclerotica had not occurred. Hence, sympathetic ophthalmia is sharply separate from the other two syndromes in spite of the fact that poliosis, alopecia and deafness may occasionally be associated with it. But, of the nontraumatic syndromes, bilateral uveitis associated with symptoms involving the integument and the hair (alopecia and poliosis always, vitiligo and auditory disturbances frequently) should be sharply differentiated from bilateral uveitis accompanied by retinal detachment (Harada's disease). In the latter syndrome alopecia and poliosis do not figure as an integral part.

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# A COLOR STEREOSCOPIC PHENOMENON

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One day while glancing over some books in a railway station bookstall the attention of one of us was attracted by a book with a shining red cover and a title printed in black and white letters. Suddenly the white letters appeared to rise from the surface of the cover and to float in a limitless red space. Some distance behind the white letters the black ones also floated in this red "mist," and they too seemed to have no contact with the surface of the book. This phenomenon appeared so interesting to us that we decided to investigate it.

Some time afterward we discovered in the literature two references to color stereoscopic phenomena, one by Angelucci and Contino and the other by Donders and Einthoven.

At the meeting of the Societa Italiana di Oftalmologica in 1925, Contino,[1] citing Angelucci, described how some artists working in stained glass for the windows of churches made use of a certain stereoscopic efficiency in their colors. Principal characters who were to occupy prominent positions in the foreground and to whom the attention of the spectator was to be attracted were dressed in red, while the less important characters were relegated to the background and obscurity by being dressed in green.

Contino explained this phenomenon by the chromasia of the eye and by the difference in dioptric value between the long wave and the short wave ends of the spectrum. Contino and, before him, Tscherning [2] found that there is a difference of 2 D. between the long wave and the short wave ends of the spectrum, which means that a red object requires a greater amount of accommodation than a blue one to bring it into focus. It is a well known fact that, for the same reason, blue is a much more

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1. Contino, A.: Influenza dei colori sul senso del rilievo, Cong. Soc. ital. di oftal. **10**:27, 1925.

2. Tscherning, M. H. E.: Optique physiologique. Dioptrique oculaire; fonctions de la rétine; les mouvements oculaires et la vision binoculaire, Paris, G. Carré & C. Naud, 1898.

restful color than red. Pillsbury and Schaefer [3] recently published a note on advancing and retreating colors. They emphasized that to most observers blue appeared nearer than red.

Donders had already described a stereoscopic phenomenon observed on the wallpaper of a room in Leipzig in 1868. The wallpaper seems to have been of a most garish pattern, for it consisted of broad horizontal and vertical stripes of bright yellow on a background of thin black vertical stripes. Observing the wall from a distance of 3 to 4 meters, Donders described how he had the impression that the yellow stripes came toward him, until they looked like a yellow lattice standing about 20 cm. in front of the dark wall. He described how the yellow lattice seemed to move "against" the wall as he moved his head from side to side.

Donders demonstrated this phenomenon to two famous scientists, Carl Ludwig and Zoellner, but could not produce the same effects with both of them.

In 1885, seventeen years later, Donders [4] again demonstrated the phenomenon with red and blue letters on a black background. The red letters seemed to rise in front of the blue ones, but other observers did not experience the phenomenon so clearly, and the effects remained uncertain. Sometimes the red would be in front and sometimes the blue.

Studying the question further, Einthoven,[5] in Donders' laboratory, found that the apparent distance between the colors was dependent on binocular vision and disappeared when one eye alone was used. He also demonstrated the parallactic movement mentioned by Donders.

Von Bruecke,[6] in his lectures on physiology, described a band composed of three sections, red in the center and blue at each end. He noticed that the red and blue seemed to be in different planes. Schoute [7] mentioned the Donders phenomenon and using blue and red objects concluded that the axial length of the eye is proportional to the apparent difference of distance between the two objects.

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3. Pillsbury, W. B., and Schaefer, B. R.: A Note on "Advancing and Retreating Colors," Am. J. Psychol. **49**:126, 1937.

4. Donders: Ueber Stereoscopie durch Farbendifferenz, Ber. ü. d. Versamml. d. ophth. Gesellsch. **18** (pt. 2):82, 1886.

5. Einthoven, W.: Stereoscopie durch Farbendifferenz, Arch. f. Ophth. (pt. 3) **31**:211, 1885.

6. Von Bruecke, E. W.: Vorlesungen über Physiologie, Vienna, W. Braumüller, 1881-1884.

7. Schoute, G. J.: Le phénomène d' Einthoven et la longeur de l'oeil vivant, Ophthalmologica **99**:282, 1940.

We thought it necessary to reconsider the original experiments of Donders, Einthoven and von Bruecke, so that we might be able to see how far our observations coincided with theirs.

We would further stress that these identical experiments were carried out with the original plates published by Einthoven [5] after we had had a considerable amount of our own experience in observing colors and when our eyes and minds were well trained to recognize stereoscopic differences.

In none of the experiments did we find uniformity of results. The first impression, that the red was in front of the blue, quickly gave place to the opposite impression, and from that moment onward the red and blue alternated with each other. Further, we discovered that while the phenomenon was more marked when observed binocularly it was still evident even when one eye was used alone.

It will be seen that with the exception of the condition of binocular vision our observations confirmed those of previous observers. But it is remarkable that Donders and his pupil Einthoven restricted their experiments to these two colors and did not consider investigating the relation of other colors, including black and white. The example chosen by Donders and his colleagues for their investigation is merely one of many such color arrangements, and it did not seem to us to be particularly happy in its choice. As a result we decided to investigate color relations with a view to their stereoscopic effect, for we had the impression that colors have a stereoscopic value to each other, not a fixed value but one dependent on certain objective and subjective factors, such as the size of the object, the intensity of the color, the proportion of white and black in the color, the quality of the illumination and the condition of the observer. We believed that a knowledge of this question might deepen and enrich the technic of painting and also throw some light on the unconscious use of these principles by painters in the past, especially those of the impressionist and postimpressionist schools.

## EXPERIMENTS

Our experiments were observed under the following conditions: the objects were placed at a distance of from 3 to 5 meters, in good diffuse daylight. The background for all the experiments was a neutral gray, and the colors used were the Ostwald series of colored papers with fixed proportions of hue, black and white and the achromatic series from white to black.

*Experiment 1.*—On a spectral red background (hue 83.4 per cent, black 11 per cent and white 5.6 per cent) a row of varied white letters, 20 mm. high, was arranged. Shortly after the white letters were fixed, they appeared to rise slightly

from the surface of the red background. On the addition of a thin black band above and below the row of letters, the stereoscopic effect became more pronounced in from ten to fifty seconds. But the most vivid impression came when the surface of the background no longer offered resistance to the eye and the red paper seemed to dissolve into a limitless red space. This difference between the surface color of a piece of paper and the limitless space color of a summer sky is well known in psychology, and in the literature on that subject the two types of color are described as surface color and film color respectively.[8] We propose to adopt this terminology when distinguishing between these two different types of color, and we will often have to note the greatly increased stereoscopic effect when the surface color merges into the film color.

Observing the experiment again, we had in a few seconds the impression that the white letters were floating in a red film color and that the black bands were some distance behind them. It will be seen from what has been said before that the addition of black greatly increased the stereoscopic effect, which may be explained in the following way: When the white is placed alone on the red, it is possible to judge the apparent stereoscopic difference only as long as the red retains its surface, but when the red becomes a film color, the white floats in a red mist which has nothing against which to relate the position of the white. The addition of a piece of black seems to solve this problem, as the black stripes do not move in front of the red space and can act as a point of comparison against which to relate the white. For want of a better term we will call this black line or shape the surface of reference.

On looking again at the experiment, we noticed that some of the larger white letters appeared nearer to us than others, and we were led to the conclusion that the area of white has some effect in bringing about the stereoscopic phenomenon.

To demonstrate this, a small white square, 8 mm. to the side, was added to the experiment. It was clearly seen that this square lay behind the bigger letters. Another white square, 6 mm. to the side, was added, which was seen to lie behind the previous one. One would expect that a large white 6 cm. square would lie far out in front of the largest letters, but this is not so. The large square lay behind the letters but in front of the first square of 8 mm. This would indicate that there is a quantitative optimum for the greatest stereoscopic effect.

*Experiment 2.*—On a background of red similar to that used in experiment 1, twenty-two vertical stripes of white, 15 mm. high and 6 mm. wide, were spaced out 10 mm. apart in a straight line. Two black isosceles triangles, measuring 3 cm. at the base and 23 cm. in height, were placed on their sides above and below the white stripes so that their bases were level with the fifth stripe from the right and their vertices level with the fifth from the left (fig. 1 *A*). The sides of the triangles farthest from the stripes were horizontal and 5 cm. from the stripes. There were four pieces of white at each end which were not directly influenced by the black. The stereoscopic effect of this experiment became evident in from twenty to thirty

8. Katz, D.: Der Aufbau der Farbwelt, ed. 2, Leipzig, Johann Ambrosius Barth, 1930.

seconds. The white floated far out in front of the black. It is most interesting to note that the white stripes not opposite the black gave the impression of receding steps and that the stripes opposite the broadest part of the black appeared to be nearest the spectator.

Observing the experiment again and numbering the white blocks from the right, no. 4 was the most prominent of the four blocks outside the black, nos. 2, 3 and 1 receding regularly from it. From no. 5 the blocks between the black triangles rose in a regular curve to nos. 8 and 9, where they began to curve gently down to no. 17. The final four blocks were on the same level as no. 17, and they were all at a lower level than the corresponding four at the right hand side.

We can conclude from this experiment that the intensity of the stereoscopic phenomenon depends not solely on the amount of white but also on the strength of the retinal stimulation from the "surface of reference."

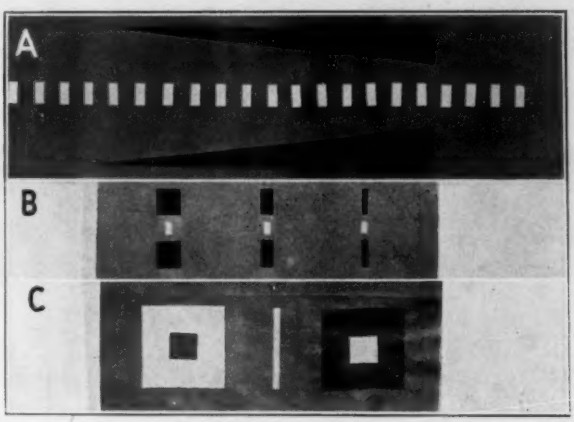


Fig. 1.—Experiment 2.

To illustrate this conclusion we devised experiment 3.

*Experiment 3.*—Three small, white rectangles, 6 by 12 mm., were placed in a straight line 10 cm. apart on a neutral gray background. A surface of reference of black, 28 mm. high, was placed 6 mm. above and below each block of white. Above the first block it was 6 mm. broad, above the second 12 mm. broad and above the third 24 mm. broad (fig. 1 *B*).

The first impression was that the white block with the largest surface of reference was in front and that the others receded regularly behind it; but on studying each block in turn it was possible to bring all the white ones to the same level but still far in front of the black ones. Sometimes, but not often, it was possible to bring the black blocks out in front of the white ones, but this was very difficult.

We concluded from this experiment that (1) no colors are necessary to produce the stereoscopic phenomenon; (2) the quantity of the surface of reference is important in the first impression, and (3) the phenomenon can be inverted at will, not easily, but after a good deal of mental effort, which proves that at least a part of the phenomenon is not physiologic but psychologic.

*Experiment 4.*—Two squares, 9 cm. to the side, of black and white were placed on a straight line 10 cm. apart. Between the two squares and on a level with them was a vertical white bar 5 mm. broad. On the center of the white square was placed a black square, 3 cm. to the side, and on the large black square a white square, 3 cm. to the side (fig. 1 *C*).

With the eyes fixed on the large white square, the small black one seemed to float in the anterior part of a white mist. With the eyes fixed on the large black square the superimposed white square was seen to float far out in front of its background and also out in front of the small black square. The white line in the middle was the nearest of all to the observer.

It was concluded that (1) the phenomenon appears independent of color and (2) the appearance of the small white band in front of the large white square demonstrates once again that the quantity of white in excess of a certain proportion does not influence the stereoscopic effect, in other words, that there is a quantitative optimum for white.

*Experiment 5.*—On a neutral gray background eight squares, 5 cm. to the side, ranging from deep black through gray to white, were arranged in a straight line 5 cm. apart. In the center of each square a small white square, 1 cm. to the side, was placed (fig. 2).

Fig. 2.—Experiment 5.

The small white square on the black square was the most outstanding, and the stereoscopic effect diminished in a regular manner down to the white square on the palest gray.

We noticed that the white square on the black was much whiter than that on the pale gray and also that it looked much larger, but these phenomena are known, and we merely noted them in passing.

From this experiment we conclude that the intensity of the contrast is important in the production of the stereoscopic phenomenon.

*Experiment 6.*—On a neutral gray background eight concentric cricles, ranging from deep black by even gradation to pure white, were arranged (fig. 3). The black circle was 20 cm. in diameter, and the superimposed circles decreased regularly by 2 cm. in diameter.

On observing the experiment, a pronounced stereoscopic effect was at once appreciated. The white circle seemed to be entirely divorced from the black ring and floated far out in front of it. The whole impression was that of a frustum of a cone.

This striking experiment is useful in demonstrating that the phenomenon is not dependent on color for its effect.

*Experiment 7.*—Chromatic Series: In the following experiments the colors used were the standard spectral hues of Ostwald's color system, containing 83.4 per cent hue, 11 per cent black and 5.6 per cent white, and the background was a neutral gray.

(*A*) Two 9 cm. squares of blue and yellow (complementary colors) were arranged on the same level on the background and 9 cm. apart. In the center of the blue square was placed a small yellow square, 3 cm. to the side, and on the large yellow square, a small blue square of similar size.

We observed that the small yellow square was in front of its blue background, which had become a film color. The small blue square was also in front of its background, but the effect was not so pronounced.

(*B*) We repeated the experiment with green and purple and obtained similar results.

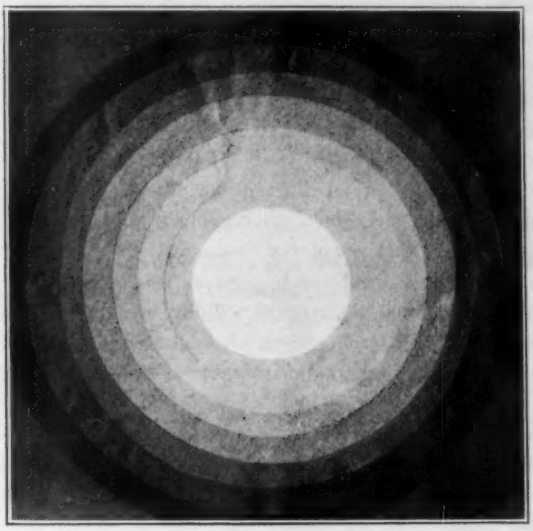

Fig. 3.—Experiment 6.

(*C*) We repeated the experiment with orange and blue-green, with similar effects.

Our conclusions from this experiment are that certain colors have a fixed stereoscopic value to each other but that the stereoscopic value is not a clear function of the complementary color, as the effect is more pronounced when the background is darker than the superimposed color.

*Experiment 8.*—Five 5 cm. squares of red were arranged in series and by even gradations from dark to light on a straight line 2 cm. apart. They were arranged in the following order:

Shade 2 (5.6 per cent white, 86 per cent black and 8.4 per cent hue), shade 1 (5.6 per cent white, 65 per cent black and 29.4 per cent hue), hue (5.6 per cent white, 11 per cent black and 83.4 per cent hue), tint 1 (14 per cent white, 11 per cent black and 75 per cent hue) and tint 2 (35 per cent white, 11 per cent black and 54 per cent hue).

In the center of each square was set a small white square, 1 cm. to the side. The experiment was repeated for green, yellow, orange and purple. The white square on the background which had the highest content of black floated farthest in front. The best impression was obtained at a distance of from 1 to 2 meters.

The most pronounced stereoscopic effect was obtained in the purple series. In the red and orange a good stereoscopic effect was distinguished only in the three darkest squares.

In the yellow-green series a good effect was seen only in the two darkest squares.

We concluded that the most intense stereoscopic effect is realized with the white square on the darkest color, that is, the color with the highest intrinsic achromatic value and the greatest proportion of black. The white squares on the darkest colors are more luminous than those on the light tints.

It is noteworthy that the most intense stereoscopic effect appears at that moment when the surface color changes into a film color. Then the colored paper dissolves into a limitless colored space.

It is interesting to note that on fixing one's eyes on each white square in turn, the square on the darkest color always appears to shrink in size as it comes forward. We would have expected from our knowledge of linear perspective that this shrinkage would have given the impression that the object was receding into the background, but this is not the case.

*Experiment 9.*—On a spectral red background two white stripes, 4 by 1 cm., were arranged vertically and horizontally. Both stripes were seen to float out in front of the red. Four black stripes of similar size were added; two were placed diagonally and the others horizontally and vertically. The horizontal black stripe was seen to be far in front of the others but still behind the white. The vertical stripe was the farthest back, and the diagonal ones occupied a central position. Sometimes it was possible by means of a conscious effort to bring the vertical black stripe out in front of the diagonal ones, but it fell back into its original place when the effort was relaxed. From these observations we concluded that the position of the retinal stimulation is important in producing the stereoscopic effect, but this effect is not a fixed one, for one can succeed in altering the relative position in space of the objects by looking at them for a considerable time. We did not succeed in bringing about this alteration in the position in space by moving the head.

*Experiment 10.*—On a background of red were spread small stripes of paper, 1 by 3 cm. These papers were of all the spectral hues and black and white, and they were spread at even distances over the background. On studying the experiment it immediately was clearly seen that there was a marked stereoscopic difference between certain of the colors. This stereoscopic difference can be clearly seen by even the most inexperienced observers and is very impressive.

White was in front of all the other colors, followed by yellow, black, light green, orange, dark green and finally blue, in that order. The colors did not represent a regular regression but rather a series of unequal steps.

The experiment was repeated with backgrounds of blue, green, yellow, black and white.

On a blue background the stereoscopic value of each color was seen to be vastly altered, and the black was in front, followed by white, purple, light green, yellow and violet, in order.

On a green background white and black were in front and red was farthest back. Blue did not have a fixed position but alternated with purple, although it remained always in the background. Yellow, white and black were always in front of red and blue.

On a yellow background the entire impression was very flat. Red was farthest in front, and immediately behind was green. The other stripes did not seem to have any definite stereoscopic value.

On a black background yellow was seen in front, with purple far behind. Orange and white lay behind the yellow, followed by green and blue.

On a white background the impression was really flat, and there was no marked stereoscopic difference between the superimposed colors.

We can summarize the results obtained from the experiments and show the change of effects created by different backgrounds in the following way:

| Background | Superimposed Colors, in Order of Stereoscopic Prominence |
|---|---|
| Red..... | White, yellow, black, light green, orange, dark green and blue |
| Blue..... | Black, white, purple, light green and violet |
| Green..... | White, black, yellow, blue and red |
| Black..... | Yellow, orange, white, green, blue and purple |
| Yellow..... | Red and green |
| White..... | A flat impression |

It will be seen that the most outstanding stereoscopic effect is obtained with a red background and that the impression becomes less and less pronounced when blue, green, black, yellow and white backgrounds, in order, are substituted for red. The final two backgrounds, yellow and white, give poor results.

*Experiment 11.*—A zone formed by two concentric circles, with diameters of 18 and 9 cm. respectively, was divided into eight equal parts, each part representing one of the eight spectral hues of the Ostwald color system. In the center of each part was placed a white square, 1 cm. to the side. The background was a neutral gray.

The apparent position in space of each white square varied with the color to which it was related. The most pronounced stereoscopic effect was in the red area, where the white square floated far out in front of its background. On the blue side of the color circle the stereoscopic effect slowly diminished as the background changed from violet through blue, blue green, green and light green to yellow. Each successive change showed the superimposed white spot floating less and less in front of its background until in the yellow-green and yellow areas the stereoscopic effect was difficult to see at all. On the blue side of the color

circle the diminution of the stereoscopic effect can be described as a series of even descending steps, with red at the top and yellow at the foot. On the red-orange side the effect also diminished as the background changed from red to orange and yellow, but on this side the steps down from red to yellow were greater than those from red to yellow on the blue side. It might be said that both sides of the circle covered the same distance from red to yellow, the blue side in six steps and the red side in only two.

The phenomenon was pronounced in a small central area of the visual field. Thus, when the red area, which was adjacent to the purple, was fixed, the stereoscopic effect of the small white square on the purple was not very pronounced; but when the attention was turned to the purple area itself, the stereoscopic effect was seen to increase at once.

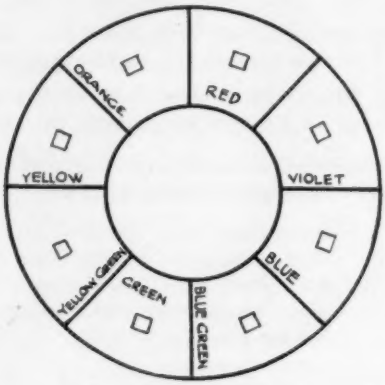


Fig. 4.—Experiment 11.

## COMMENT

We recommend that a series of experiments, such as we have devised in experiment 11, be worked out with all the spectral colors—not only white—so that a complete record of the behavior of colors on certain backgrounds could be obtained. This would be of some value for teaching purposes for artists, as well as psychologists.

We tried in several experiments to increase the stereoscopic effect by using a stenopaic hole for one eye, but while in some cases we did have the impression that the stereoscopic value was increased under this condition, usually the only effect observed was a dimming of the general impression. This attempt to prove the stereoscopic effect of colors by the method of Pulffrich's phenomenon failed completely. We believe that the basis of this stereoscopic phenomenon of color lies in the fact that the background, after it has been observed for some time, changes from a surface color to a film color and that the colors placed on it then take up their various positions in this colored space.

We have not been able to offer any explanation as to how this change from surface to film color comes about, but we have had to accept the fact. We have noted, however, that this change does not happen immediately on the observation of a colored surface but that it requires an element of time to bring it about and that the transition from surface to film color is a comparatively slow one.

Looking once more at experiment 10, this time with a ruby red glass before each eye, we saw the red background as a pinkish gray and the white stripes as light pink. The black stripes remained unchanged. The stereoscopic positions of the various stripes remained unaltered, the pink stripes being still out in front of the black ones and the horizontal black stripes in front of the diagonal and vertical ones. The general stereoscopic effect was slightly diminished.

We did not succeed in explaining the anatomic or physiologic basis of our phenomenon. Donders, Einthoven and Contino gave the fact that the emmetropic eye requires an act of accommodation to bring the red rays, which converge behind its retina, into focus as the explanation for their phenomenon of the red appearing in front of the blue, but as we were able to demonstrate our phenomenon with all colors as well as the achromatic series and as our observations were often capable of being inverted, we are of the opinion that this explanation does not hold good for our phenomenon.

The inversibility of our phenomenon with certain pairs of colors lead us to expect that psychologic influences of great importance play a part in bringing about the phenomenon, but, on the other hand, the fact that certain colors have a definite fixed position not affected by will leads us to believe that there must also be some physiologic basis for the reaction.

Our stereoscopic phenomenon belongs to the great group of contrast manifestations of reciprocal effect. Now that we have become conscious of the stereoscopic phenomenon we find it everywhere, on posters and billboards and especially on books in bookstalls, and now we are really haunted by it. An understanding of this phenomenon will be of great value to the practicing artist, for he must know the stereoscopic effect of certain colors, especially colors to be used for backgrounds, in order that he may be able to control and use this effect in his painting.

We hope to be able to show how much the great masters have used this stereoscopic effect unconsciously in their work in another place.

## SUMMARY

When certain colors are placed on colored backgrounds and observed for some time, the backgrounds change from surface color to colored spaces in which the superimposed colors seem to float. On a standard red background (Ostwald series) white stripes float far in front of the

red mist, and this impression of space becomes much more striking when the white stripes are combined with black, for it is easily seen that there is a great difference in depth between the white and the black. The position in space of these superimposed colors is determined partly by their color and partly by their size, larger spots being appreciated in front of smaller ones, although there exists a certain quantitative optimum for the greatest stereoscopic effect.

The intensity of the stereoscopic effect of the aforementioned example depends not only on the size of the white area but also on the intensity of the black or, as we have called it, the surface of reference, and it is seen that the same area of white has a greater stereoscopic value when the area of the surface of reference is increased.

To produce a stereoscopic effect colors are not necessary, for we succeeded in many experiments using only black, white and a neutral gray background. The phenomenon is also clearly seen monocularly, but the impression is much stronger when the experiment is viewed binocularly.

The use of a stenopaic hole for one eye in the hope of proving the phenomenon according to the theory of the Pulffrich phenomenon was not successful. We found that by conscious effort we were able with certain combinations of color to invert the phenomenon, and we were reminded by this of the well known step phenomenon of Schroeder and also of the reciprocal effect exerted on each other by adjacent objects in certain optical illusions.

We have reached the conclusion that some psychologic factors at present unknown play a great part in producing the phenomenon described here, but we also feel sure that the basis of the entire subject is a physiologic one.

# RETINA IN SYSTEMIC VASCULAR HYPERTENSION

## A CLINICAL STUDY OF THE CALIBER OF THE RETINAL ARTERIOLES AND THE RETINAL ARTERIAL DIASTOLIC BLOOD PRESSURE

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NEW YORK

My interest in the application of vascular micrometry to the clinical differentiation of diffuse vascular disease with hypertension was aroused by the work of Lobeck [1] in 1937. In his paper he stated that the caliber of the retinal vessels in cases of red and of pale hypertension (Volhard's [2] classification) differed definitely from that of normal persons. Kühn,[3] as did Badtke [4] in the same year, confirmed his findings for normal persons. Badtke also examined several groups of hypertensive patients, his results supporting in the main those of Lobeck. Lo Cascio [5] in 1926 and Neame [6] in 1936, in offering measuring procedures of their own, already had suggested that it might be possible to depend on retinal vascular measurements in the clinical grouping of patients with pathologic elevation of the systemic blood pressure.

Intraocular micrometry began with Zander [7] in 1864; thereafter many workers offered numerous methods and procedures for the measurement

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From the Institute of Ophthalmology, Presbyterian Hospital.

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Abridgment of a thesis submitted to the faculty of the Graduate School of the University of Minnesota in partial fulfilment of the requirements for the degree of Master of Science in Ophthalmology.

1. Lobeck, E.: Ueber den Durchmesser der Netzhautgefässe am gesunden und kranken Menschen, Arch. f. Ophth. **136**:439-456, 1937.

2. Volhard, F.: Elevated Blood-Pressure, in Berglund, H., and Medes, G.: The Kidney in Health and Disease: In Contributions by Eminent Authorities, Philadelphia, Lea & Febiger, 1935, pp. 387-416.

3. Kühn, W.: Ueber Messungen am Augenhintergrunde, Arch. f. Ophth. **138**: 129-148, 1937.

4. Badtke, G.: Kalibermessungen an den Netzhautgefässen bei Hochdruck- und Nierenkranken, Klin. Monatsbl. f. Augenh. **99**:655-669 (Nov.) 1937.

5. Lo Cascio, G.: Ricerche cliniche, anatomo-pathologiche e patogenetiche sulla neuroretinite nefritica, Ann. di ottal. e clin. ocul. **54**:3-64 (Jan.) 1926.

6. Neame, H.: A Method of Estimating the Calibre of Retinal Arteries in the Living Eye by Means of the Ophthalmoscope, Illustrated by Results in Some Normal and Pathological Cases, Tr. Ophth. Soc. U. Kingdom **56**:155-162, 1936.

7. Zander, A.: The Ophthalmoscope: Its Varieties and Its Uses, translated by R. B. Carter, London, Robert Hardwicke, 1864, p. 101.

of structures within the eyes of living human beings. There are today two principal methods for measuring these structures in one plane: (1) use of some form of the grid, or graticule, with various methods of ophthalmoscopic examination or in conjunction with retinal photography and (2) the heliometric method of Lobeck,[8] which he introduced in 1934 for use with the Gullstrand ophthalmoscope. Correction factors, however, must be employed with any method.

Lobeck found that in comparison with his normal values there existed a definite decrease in the diameters of the retinal arteries in his cases of red hypertension and that this decrease in caliber was accentuated in cases of genuine nephrosclerosis and was still more marked in cases in which albuminuric retinitis was present. This was true also in cases of malignant hypertension and in those of chronic glomerulonephritis with elevated brachial blood pressure but without retinitis. Badtke, using Lobeck's method, reported measurements that in the main were in agreement with those of Lobeck except that the values he obtained in cases of red hypertension exceeded those he obtained for normal persons. He attempted to justify this finding of dilatation in association with red hypertension by a dissertation on his views on the abnormal physiology of hypertensive disease. Both of these workers concerned themselves also with determination of the arteriovenous size relation, or ratio, based on the actual values they obtained.

The increased interest in the ophthalmodynamometer for clinical use began with the introduction of the apparatus offered by Bailliart[9] in 1917. Bajardi[10] in 1906 probably devised the first of these dynamometric instruments, although Henderson,[11] who converted a Geneva lens measure to this purpose in 1914, generally is given the credit. Dynamometers operating on a standardized spring tension have been offered, among others, by Baurmann,[12] Spinelli,[13] Sobánski,[14] Kukán[15] and

8. Lobeck, E.: Ueber Messungen am Augenhintergrund, Arch. f. Ophth. **133**: 152-156, 1934.

9. Bailliart, P.: Circulation artérielle rétinienne; essais de détermination de la tension artérielle dans les branches de l'artère centrale de la rétine, Ann. d'ocul. **154**:257-271, 1917.

10. Bajardi, cited by Rubino, C.: La pressione del sangue nell'arteria retinica e suoi rapporti con la pressione nel circolo del Willis, Riforma med. **27**:1345-1354 (Dec. 4) 1911.

11. Henderson, T.: Clinical Proof of the Venous Level of the Intra-Ocular Pressure and a Method of Estimating the Arterial Diastolic Pressure in the Eye and Its Clinical Significance, Tr. Ophth. Soc. U. Kingdom **34**:309-315, 1914.

12. Baurmann, M.: Vergleichende Blutdruckmessungen an den Gefässen des Auges, Arch. f. Ophth. **118**:118-130, 1927.

13. Spinelli, F.: Angiotensiometro retinico Spinelli, Atti cong. Soc. ital. di oftal. (1934) **32**:795-798, 1935.

Keil.[16] The apparatus of Uyemura and Suganuma[17] depends on the steady application of the hydrostatic pressure. The values for retinal arterial pressure obtained with these instruments by many workers during the past two decades are in agreement in the main, although rather a wide range of values has been reported. The findings of Suganuma[18] have been questioned by Müller, Brüning and Sohr,[19] who stated that his values for normal persons are approximately 15 per cent higher than those reported by themselves and by other workers with the dynamometers of Bailliart and of Sobánski.

Bailliart, his co-workers and his followers expressed the opinion that ophthalmodynamometric studies almost invariably are of great clinical importance as a diagnostic aid in the clinical differentiation of types of diffuse vascular disease with hypertension. These investigators claimed that it is entirely possible to detect early pathologic elevations of the systemic blood pressure, to determine the severity or stage of established hypertension and even to recognize the latent, or "prehypertensive," phase. They stated the belief that use of the ophthalmodynamometer by adequately trained persons is a more refined diagnostic procedure than use of the ophthalmoscope by such persons.

## PURPOSE OF STUDY

The ophthalmodynamometer of Bailliart had been in occasional use for some years at the Mayo Clinic when the reports of Bailliart[20] and of others before the fifteenth International Congress of Ophthalmology in Cairo, Egypt, in 1937 minimized the usefulness of ophthalmoscopic

14. Sobánski, J.: Ein Ophthalmodynamotonometer und seine Handhabung, Klin. Monatsbl. f. Augenh. **96**:351-356 (March) 1936.

15. Kukán, F.: Ergebnisse der Blutdruckmessungen mit einem neuen Ophthalmodynamometer, Ztschr. f. Augenh. **90**:166-191 (Oct.) 1936.

16. Keil, J.: Ein neues Ophthalmodynamometer, Klin. Monatsbl. f. Augenh. **99**:625-636 (Nov.) 1937.

17. Uyemura, M., and Suganuma, S.: Ueber einen neuen Ophthalmodynamometer, Acta Soc. ophth. jap. **38**:1835-1844, 1934.

18. Suganuma, S.: Studien über den Blutdruck in der Zentralarterie der Netzhaut. I. Mitteilung. Ueber den Blutdruck in der Zentralarterie der Netzhaut bei gesunden Menschen und über seine Beziehung zum allgemeinen Blutdruck, Klin. Monatsbl. f. Augenh. **96**:74-84 (Jan.) 1936; Studien über den Blutdruck in der Zentralarterie der Netzhaut. II. Mitteilung. Ueber der Blutdruck in der Zentralarterie der Netzhaut bei verschiedenen Formen von allgemeiner Hypertonie und über die sog. isolierte zephale Hypertension, ibid. **97**:498-514 (Oct.) 1936.

19. Müller, H. K.; Brüning, A., and Sohr, H.: Die Eichung der Dynamometer von Bailliart und Sobanski am menschlichen Leichenauge, Tr. Internat. Ophth. Cong. (1937) **4**:44-51, 1938.

20. Bailliart, P.: L'hypertension artérielle rétinienne (partie clinique), Tr. Internat. Ophth. Cong. (1937) **1**:87-142, 1938.

examination and emphasized the supposed greater value of dynamometric readings in the differentiation of various types and stages of systemic hypertensive disease. It therefore was determined to employ this apparatus in conjunction with the Morgan [21] graticule in the Keeler ophthalmoscope for measurements of arteriolar diameters in a clinical study of a series of normal persons as well as patients who had chronic glomerulonephritis and patients with diffuse arteriolar disease with hypertension, the latter being classified into four groups according to the criteria of Wagener and Keith.[22]

It was the purpose of this study to determine whether it was possible clinically to establish consistent variations from the normal in the retinal arteriolar diameters and the retinal diastolic blood pressure of patients with these various hypertensive states. It seemed desirable also to determine whether the values obtained would be of aid in grouping, or classifying, these patients according to their condition.

## CLINICAL INVESTIGATION

A total of 300 patients with 598 eyes were examined (table 1). No attempt was made to differentiate as to sex, habitus or ethnologic derivation. The arbitrary values established by Wetherby [23] of 150 mm. of mercury systolic and 90 diastolic were taken as representative of the upper limits of normal brachial blood pressure.

The patients were placed according to age in three subgroups as follows: 8 to 15, 16 to 40 and 41 to 60 years, inclusive, since the impression existed on the basis of ophthalmoscopic observations that the arterioles generally are of greater caliber in persons of middle age and of smallest caliber in persons 15 years of age or less. It was thought that the measurements might confirm this impression. Of the patients, 184 showed no evidence of systemic vascular disease, 7 had chronic glomerulonephritis without retinitis and 109 had primary hypertensive disease.

Measurements of the diameters of the retinal arterioles were carried out after the ophthalmodynamometric readings had been determined. Ophthalmoscopic examination followed these procedures. The values recorded in the tables were evolved from the actual measurements or readings obtained and were reduced to the closest convenient units to

21. Morgan, O. G.: A Retinal Graticule, Brit. J. Ophth. **11**:339-341 (July) 1927.

22. Wagener, H. P., and Keith, N. M.: Diffuse Arteriolar Disease and Hypertension and the Associated Retinal Lesions, Medicine **18**:317-430 (Sept.) 1939.

23. Wetherby, M.: A Comparison of Blood-Pressure in Men and Women: A Statistical Study of 5540 Individuals, in Berglund, H., and Medes, G.: The Kidney in Health and Disease: In Contributions by Eminent Authorities, Philadelphia, Lea & Febiger, 1935, pp. 370-386.

avoid decimalization. Tonometric readings were not taken, but since none of the subjects showed evidence of elevated intraocular pressure, the average value of 20 mm. of mercury accepted as normal by Duke-Elder [24] was used as the basis on which the actual dynamometric readings in grams of water were converted into millimeters of mercury from the graph of Magitot and Bailliart.[25]

*Vascular Micrometry.*—It has been the custom of the majority of the preceding investigators to determine the caliber of only one or, at the most, two retinal vessels at or very near the margin of the disk of only one eye. Not infrequently this procedure resulted in measurements of the diameter of the papillary arteries instead of the retinal arterioles. Wagener [26] measured nasal and temporal arterioles at a point ½ disk diameter from the margin of the disk in his study of changes in caliber associated with cervicothoracic ganglionectomy. Cusick and Herrell [27]

TABLE 1.—*Classification of Patients into Groups According to Condition and Age*

| | Age in Years, Inclusive | | | |
|---|---|---|---|---|
| | 8 to 15 | 16 to 40 | 41 to 60 | Total |
| Normal persons | 28 | 110 | 46 | 184 |
| Patients with chronic glomerulonephritis | 0 | 5 | 2 | 7 |
| Patients with hypertension: | | | | |
| Group 1 | 0 | 13 | 37 | 50 |
| Group 2 | 0 | 7 | 24 | 31 |
| Group 3 | 0 | 4 | 17 | 21 |
| Group 4 | 0 | 4 | 3 | 7 |
| Total | 28 | 143 | 129 | 300 |

followed a similar procedure in their investigations of the effect of tobacco and cold on the systemic blood pressure. Cotton, Lewis and Egenhofer,[28] using the Lobeck method and correcting formulas of their own, recently have obtained values which they thought represented the entire retinal vascular bed. They found that moderate refractive errors caused little, if any, appreciable inaccuracy.

24. Duke-Elder, W. S.: The Ocular Circulation: Its Normal Pressure Relationships and Their Physiological Significance, Brit. J. Ophth. **10**:513-572 (Oct.) 1926.

25. Magitot and Bailliart: Modifications de la tension oculaire sous l'influence de pressions exercées sur le globe (recherches expérimentales), Ann. d'ocul. **156**: 656-666, 1919.

26. Wagener, H. P.: Ocular Changes Following Cervicothoracic Sympathetic Ganglionectomy, S. Clin. North America **11**:867-873 (Aug.) 1931.

27. Cusick, P. L., and Herrell, W. E.: Retinal Arteriolar Changes as Part of an Induced General Vasospastic Reaction: Effect of Tobacco and Cold, Arch. Ophth. **21**:111-117 (Jan.) 1939.

28. Cotton, J. M.; Lewis, N. D. C., and Egenhofer, A. W.: Vascular Bed of the Retina in Mental Disease, Arch. Neurol. & Psychiat. **43**:891-900 (May) 1940.

It was not feasible in this study to measure all the retinal vessels and their branches, but it was possible to determine the caliber of each of the four main retinal arteriolar trunks in each eye (table 2). These vessels were measured as nearly as possible at a distance of 1 disk diameter from the margin of the disk. When branching occurred before the point selected for measurement the larger branch was the one examined. A table of equivalents was devised to facilitate the conversion into microns of the estimated measurements obtained with the Morgan graticule incorporated in the Keeler ophthalmoscope.

It will be observed from table 2 that the smallest mean values were found consistently for the inferior nasal arteriole of normal persons of all ages. For the superior nasal arteriole the mean value was slightly greater; for the superior temporal arteriole it was greater than for the superior nasal arteriole but less than for the inferior temporal arteriole. The last consistently had the greatest caliber. The micrometric measure-

TABLE 2.—*Mean Caliber of Retinal Arterioles of Normal Persons*

| | Age in Years, Inclusive | | |
|---|---|---|---|
| | 8 to 15 | 16 to 40 | 41 to 60 |
| Inferior nasal, microns | 63 | 70 | 66 |
| Superior nasal, microns | 70 | 79 | 74 |
| Superior temporal, microns | 91 | 110 | 102 |
| Inferior temporal, microns | 101 | 116 | 111 |
| Mean, microns | 81 | 94 | 88 |

ments confirmed the ophthalmoscopic impression that the largest-calibered retinal arterioles are to be found among persons between 16 and 40 years of age, inclusive. In persons between 41 and 60 the mean caliber is somewhat smaller, while in normal persons 15 or under it is less than that in any other age group. It is possible that the mean caliber normally is smallest in the youngest age group because these persons generally have not yet attained full maturity. The arterioles may become smaller normally in the older age group because of decreased functional activity.

The relation of the mean caliber of all retinal arterioles to the brachial blood pressure is given in table 3. The caliber, which progressively diminished from the normal through the four hypertension groups, was roughly inversely proportional to the progressive increase in systemic blood pressure from group to group, although there was wide overlapping of the values. There was no consistent difference in the caliber of the arterioles according to age in the patients with hypertension except that in hypertension group 1 (patients with relatively benign hypertensive disease) the mean diameter definitely was greater for persons 40 years of age or less than for persons between 41 and 60.

The range of systemic blood pressure in table 3 is given without regard to age. The range of values for both the systolic and the diastolic pressure generally is wider in the less advanced than in the more severe phases of diffuse vascular disease with hypertension. This is in accord with the recent observations of Mountain and Allen,[20] who found a greater variability in systemic pressure for persons in the earlier stages of hypertension than for either normal persons or patients in the more advanced stages of hypertension.

The diameters of the retinal arterioles of patients with chronic glomerulonephritis, as shown in table 3, apparently were inconsistent with those obtained for the normal persons and the hypertensive patients. It will be recalled (table 1) that 5 patients between 16 and 40 years of age and 2 from 41 to 60 were examined. The mean range of systemic

TABLE 3.—*Mean Caliber of All Retinal Arterioles in Relation to Brachial Blood Pressure*

| Grouping | Age in Years, Inclusive | | | Range of Brachial Blood Pressure, Mm. of Mercury | |
|---|---|---|---|---|---|
| | 8 to 15 | 16 to 40 | 41 to 60 | | |
| | Caliber of Retinal Arterioles, Microns | | | Systolic | Diastolic |
| Normal persons | 81 | 94 | 88 | 80 to 150 | 50 to 90 |
| Patients with chronic glomerulonephritis | .. | 67 | .. | 125 to 180 | 75 to 130 |
| | .. | .. | 90 | 110 to 130 | 75 to 90 |
| Patients with hypertension: | | | | | |
| Group 1 | .. | 83 | 74 | 140 to 180 | 80 to 120 |
| Group 2 | .. | 68 | 67 | 155 to 240 | 95 to 140 |
| Group 3 | .. | 58 | 61 | 160 to 170 | 115 to 150 |
| Group 4 | .. | 47 | 45 | 200 to 280 | 140 to 155 |

blood pressure for these two age subgroups is given in table 3. The 2 older patients had normal ranges. Three of the younger patients had a pathologic elevation of the systolic pressure, while 1 of them had a mean diastolic pressure of 130 mm. of mercury on repeated examinations. None of the 7 had retinitis. It would appear significant, however, that the caliber of the retinal arterioles definitely was greater in the patients whose blood pressure was normal than in those who had a pathologic elevation.

Table 4, in particular, graphically indicates the rather wide overlapping from group to group of the range of caliber of all the retinal arterioles. The smallest values recorded generally represent measurements of the nasal arterioles, while the largest represent those of the temporal arterioles. Although a roughly inversely proportional relation again seems to exist between the mean values for the blood pressure in

29. Mountain, G. E., and Allen, E. V.: Vascular Clinics: XV. Fluctuation of Blood Pressure in Essential Hypertension, Proc. Staff Meet., Mayo Clin. **16**:260-263 (April 23) 1941.

millimeters of mercury and the calibers of all the retinal arterioles in microns, it is impossible to determine unequivocally on the basis of a single examination in which hypertension group a certain patient should be placed even if all the arterioles were examined, since dimensions of the arterioles overlapped considerably not only from patient to patient but from group to group.

The mean percentage decrease in caliber of the retinal arterioles increases definitely from hypertension group 1 to 4 (table 4). It would

TABLE 4.—*Decrease in Caliber of All Retinal Arterioles in Relation to Blood Pressure, Without Reference to Age*

| Grouping | Number of Patients | Mean Blood Pressure, Mm. of Mercury | Caliber of All Retinal Arterioles, Microns | | Mean Decrease in Caliber from the Normal, Percentage |
|---|---|---|---|---|---|
| | | | Range | Mean | |
| Normal persons | 184 | 120/ 80 | 47 to 140 | 91 | .. |
| Patients with chronic glomerulonephritis | 7 | 135/ 90 | 37 to 124 | 74 | 19 |
| Patients with hypertension: | | | | | |
| Group 1 | 50 | 160/100 | 46 to 124 | 77 | 15 |
| Group 2 | 31 | 195/120 | 31 to 111 | 67 | 26 |
| Group 3 | 21 | 210/130 | 31 to 111 | 60 | 34 |
| Group 4 | 7 | 255/145 | 31 to 94 | 46 | 49 |

TABLE 5.—*Relation of Caliber to Percentage Decrease in Caliber of All Retinal Arterioles*

| Grouping | Range of Caliber, Microns | Range of Decrease in Caliber from Normal, Percentage | Mean Decrease in Caliber, Percentage |
|---|---|---|---|
| Normal persons | 47 to 140 | | |
| Patients with chronic glomerulonephritis | 37 to 124 | 0 to 43 | 19 |
| Patients with hypertension: | | | |
| Group 1 | 46 to 124 | 0 to 31 | 15 |
| Group 2 | 31 to 111 | 8 to 46 | 26 |
| Group 3 | 31 to 111 | 17 to 49 | 34 |
| Group 4 | 31 to 94 | 41 to 60 | 49 |

seem possible to determine the correct clinical group of the patient with hypertensive disease on the basis of this decrease. Unfortunately, however, as table 5 shows, there is considerable variation in the percentage decrease in caliber in individual patients in the various groups, so that it is impossible to state on the basis of percentage decrease of arteriolar caliber alone, any more than on the basis of blood pressure readings alone, to which of the four groups a particular patient with hypertension really belongs.

*Ophthalmodynamometry.*—The relation of the retinal diastolic to the brachial diastolic blood pressure as estimated in millimeters of mercury was studied with reference both to the range of values obtained and to

their percentage ratios (table 6). The higher values in the ranges of percentage ratios differ little, if any, from one age subgroup to another; however, the lower ratios tend to become slightly higher from the youngest through the oldest age subgroup. Considerable overlapping and general similarity of figures exist from one age subgroup to another, although the mean percentage ratio was lowest in the youngest and highest in the oldest age subgroup.

There were definite successive increases in the values for the retinal and the brachial diastolic blood pressure in millimeters of mercury as the hypertensive disease became progressively more severe (table 7).

TABLE 6.—*Retinal and Brachial Diastolic Blood Pressure in Normal Persons*

| Age in Years, Inclusive | Range of Blood Pressure, Mm. of Mercury | | Ratio of Retinal to Brachial Pressure, Percentage | |
|---|---|---|---|---|
| | Brachial | Retinal | Range | Mean |
| 8 to 15 | 50 to 90 | 20 to 32 | 25 to 50 | 36 |
| 16 to 40 | 60 to 90 | 24 to 41 | 27 to 53 | 40 |
| 41 to 60 | 60 to 90 | 29 to 41 | 34 to 51 | 43 |

TABLE 7.—*Caliber of All Retinal Arterioles in Relation to Brachial and to Retinal Diastolic Blood Pressure, Without Reference to Age*

| Grouping | Number of Patients | Caliber of All Arterioles, Microns | Total Mean Blood Pressure, Mm. of Mercury | | Ratio of Retinal to Brachial Diastolic Pressure, Percentage |
|---|---|---|---|---|---|
| | | | Brachial | Retinal | |
| Normal persons | 184 | 91 | 75 | 31 | 40 |
| Patients with chronic glomerulonephritis | 7 | 74 | 90 | 42 | 45 |
| Patients with hypertension: | | | | | |
| Group 1 | 50 | 77 | 100 | 47 | 47 |
| Group 2 | 31 | 67 | 120 | 63 | 52 |
| Group 3 | 21 | 60 | 130 | 77 | 59 |
| Group 4 | 7 | 46 | 145 | 101 | 68 |

The percentage ratio of the retinal to the brachial diastolic blood pressure also increased progressively. It can be noted, too, that the caliber became progressively diminished from the normal through the successive groups and was roughly inversely proportional to the values obtained for the retinal vascular pressure.

On the basis of the ranges and mean values for the retinal diastolic blood pressure as shown in table 8, it would seem that it might be possible to learn whether the hypertensive disease had become sufficiently severe to have produced retinitis either with or without papilledema. The measurements obtained were reevaluated to provide arbitrary levels for local and systemic blood pressure that would permit clinical demarcation between the less severe and the more severe types of diffuse arteriolar disease with hypertension. Thus, it was found in general that the percentage ratio for the retinal to the brachial blood pressure

for all the normal persons, the patients who had chronic glomerulonephritis and the majority of those in hypertension groups 1 and 2, on the basis of individual values, was 55 or less (table 8). Conversely, as the hypertensive disease increased in severity, the number of patients who had a ratio of 55 per cent or more progressively increased; on this basis, all the patients in hypertension group 4 exhibited an abnormally high ratio.

These values might be thought to indicate that ophthalmodynamometric readings in themselves would be a sufficient basis for the

TABLE 8.—*Ratio of Retinal to Brachial Diastolic Blood Pressure, in Relation to Number and Percentage of Patients Displaying Lower and Higher Values for Such Ratio, Without Reference to Age*

| Grouping | Retinal to Brachial Diastolic Blood Pressure, Percentage Ratio | | Number of Patients | | Percentage of Patients | |
|---|---|---|---|---|---|---|
| | Range | Mean | Ratio Below 55 per Cent | Ratio Above 55 per Cent | Ratio Below 55 per Cent | Ratio Above 55 per Cent |
| Normal persons | 25 to 53 | 40 | 184 | 0 | 100 | 0 |
| Patients with chronic glomerulonephritis | 35 to 50 | 45 | 7 | 0 | 100 | 0 |
| Patients with hypertension: | | | | | | |
| Group 1 | 35 to 73 | 47 | 42 | 8 | 84 | 16 |
| Group 2 | 41 to 70 | 52 | 22 | 9 | 70 | 30 |
| Group 3 | 49 to 72 | 59 | 7 | 14 | 33 | 67 |
| Group 4 | 62 to 73 | 68 | 0 | 7 | 0 | 100 |

TABLE 9.—*Percentage Ratio of Retinal to Brachial Diastolic Blood Pressure, in Relation to Brachial Diastolic Blood Pressure, Without Reference to Age*

| Grouping | Percentage Ratio | | Brachial Diastolic Pressure, Mm. of Mercury |
|---|---|---|---|
| | Range | Mean | |
| Normal persons | 25 to 53 | 40 | Below 90 |
| Patients with hypertension, all groups | 36 to 73 | 50 | Below 115 |
| Patients with hypertension, all groups | 35 to 73 | 56 | Above 115 |

classification of elevated blood pressure with reference to the severity of the hypertensive disease. A classification on this basis probably is not only impractical but impossible of fulfilment, as indicated by the values given in table 8 for the ranges of the ratio of the retinal to the brachial diastolic blood pressure on which the percentage ratios are based. Similarly, as shown in table 9, the mean values for the percentage ratio were found to be roughly proportional to the increasing elevation of the systemic blood pressure. There was, however, considerable overlapping in the ranges of individual percentage ratios for the patients with values above and below the arbitrarily chosen levels of systemic blood pressure. It is obviously impossible, then, on the basis of correlation of the mean values and the range of percentage ratios with the height of the brachial blood pressure, in spite of attempts

to assume certain arbitrary or absolute values, to distinguish between normal persons and patients who have benign or severe hypertensive disease.

It will be seen also from table 9 that, although the mean percentage ratios in the hypertension groups above and below the arbitrary level of 115 mm. of mercury vary but slightly, only a negligible difference exists with regard to the ranges of the percentage ratios. These values definitely are lower for the normal persons, in whom the diastolic blood pressure did not exceed 90 mm. of mercury; however, there is obvious overlapping, on the basis of the actual measurements, in the values obtained for normal persons and those obtained for the patients in hypertension groups 1 to 4, inclusive.

## COMMENT

It is now established that of the several abnormal physiologic processes which may give rise to hypertension the development of increased resistance in the peripheral circulation probably is of primary and greatest importance. Although it is thought that this increased resistance probably is due initially to generalized vasoconstriction of the small arteries and arterioles in essential hypertension and in chronic nephritis, the primary etiologic factor remains obscure. Examinations with the ophthalmoscope in the early phases of hypertensive disease reveal an essentially smooth generalized reduction in caliber of the retinal arterioles as an expression of this continued arteriolar hypertonus. Lo Cascio, Neame, Lobeck and Badtke have demonstrated by means of measurements of the caliber of some of the retinal arterioles in the living human eye that these vessels undergo generalized narrowing. They found that the reduction in caliber was proportional to the severity of the hypertensive disease according to the classification of Volhard.

The vascular micrometric values obtained in the present study, however, indicate that on the basis of individual measurements alone it is impossible to establish unequivocally the clinical diagnosis in the various phases of hypertensive disease. It is apparent also that while the individual measurements were not reliable in this respect, the mean values confirmed the soundness of classifying patients with hypertension on the basis of the retinal changes in accord with the four groups of Keith and of Wagener. On correlating this classification with that of Volhard it was found that the individual values as well as the ranges of caliber in this study generally were in closer accord with the findings of Lobeck than with those of Badtke. The former gave no mean values in his study, but those recorded by the latter are in general agreement with my findings except for two groups of patients for whom his values both

for ranges and for means are appreciably higher. Thiel [30] has accepted the work of Badtke as being in accord with the theories of Volhard.

For patients with red hypertension (Volhard's classification), which corresponds more or less closely to the hypertension of patients in group 1 (Keith and Wagener), Badtke's mean value for the retinal arteriolar calibers was 50 per cent greater than mine and 10 per cent greater than that for his subjects who had normal blood pressure. The mean caliber for my patients with chronic glomerulonephritis and a normal brachial diastolic blood pressure was almost identical with that of the normal persons I studied, but Badtke's values for patients with nephritis were nearly 25 per cent lower than mine. Although he did not give the actual figures for the systemic blood pressure for his 56 patients with red hypertension and although he examined only 25 normal persons, it is possible that he encountered a group of patients whose condition might better have been classified as diffuse arterial disease with atherosclerosis. Therefore, it might be reasonable to suppose that the relative retinal vascular widening that he observed was subsequent to a relative elevation of the brachial systolic blood pressure with associated diminution of the normal elasticity of the larger arteries.

It has been shown that similar, if not more striking, difficulties exist with regard to the classification of patients with hypertension on the basis of individual measurements with ophthalmodynamometric methods in general. Most of the workers with the Bailliart apparatus, as well as those with similar instruments, have stated that it is not always possible to determine the exact or theoretically normal retinal blood pressure. This is particularly true of the diastolic pressure, and reports in the available literature indicate that, at best, this is an understatement. Duke-Elder in 1926, in reviewing the normal pressure relations of the ocular circulation, aptly observed:

> The unwieldly literature that has accumulated upon the subject is swollen with wearisomely protracted and often acrimonious discussions of unnecessary hypotheses with defective and confused experiments based on unsound physiological reasoning, with a multitude of theorizing and a paucity of facts.

Although widely varying ranges for the retinal blood pressure have been recorded by at least fifty workers with either manometric or dynamometric methods, it appears that the accepted values range from 25 to 35 and 50 to 80 mm. of mercury for the diastolic and the systolic intraocular blood pressure, respectively. Tuyl [31] appears to have been one of the few investigators to have cautioned that, at best, the values

30. Thiel, R.: Die Bedeutung der Augenuntersuchung für die Diagnose und Differentialdiagnose der Hochdruck- und Nierenkrankheiten, Tr. Internat. Ophth. Cong. (1937) **2**:201-209, 1938.

31. Tuyl, A., in discussion on Espildora-Luque.[34]

obtained on ophthalmodynamometric examination are only comparative or relative and that wide variations constantly are to be expected. This opinion is supported by the findings obtained in this study and is consistent with the fluctuating behavior of the brachial diastolic blood pressure of normal persons and of hypertensive patients.

The followers of Bailliart agree with him that the retinal diastolic blood pressure normally closely approximates 45 per cent of the brachial diastolic blood pressure at any examination. They have stated that a variation of more than 5 to 10 mm. of mercury from this theoretic ideal constitutes a finding of considerable clinical diagnostic value. In their opinion, the presence of an increase or a decrease in the level of the local retinal or cephalic vascular pressure indicates that a general physical examination will reveal hypertension or hypotension which may be systemic or cerebral in origin, provided no local ocular cause for the variation can be demonstrated.

Since 1924, when Bailliart, Magniel and Saragea [32] concluded from their dynamometric findings in 22 cases of hypertension that elevated, abnormal, relatively disproportionate values probably are found consistently in cases of pathologic elevation of the systemic blood pressure, numerous similar contributions have been made. The retinal diastolic blood pressure in a series of cases studied by Bailliart, Magniel and Saragea ranged from 20 to 120 mm. of mercury, while the systemic diastolic pressure varied from 50 to 180 mm. The percentage ratios ranged from 33 to 96.

The most recent work and the most comprehensive in general has been that of Suganuma; unfortunately, however, the findings of Müller, Brüning and Sohr indicate that his values are not altogether comparable to those obtained by other workers, since his basic curve for the conversion of the dynamometric readings into millimeters of mercury is unlike that for use with the dynamometers of Bailliart and Sobánski.[33] In general, however, Suganuma confirmed the findings of others with regard to the disproportionate relation between the retinal and the brachial diastolic blood pressure in groups of cases of general hypertensive disease. An analysis of his values and those of others, however, as well as those obtained in this study, indicates that it is impossible on the basis of individual ophthalmodynamometric readings alone to classify patients with hypertension in categorical groupings according to the methods of Volhard and of Keith and Wagener.

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32. Bailliart, Magniel and Saragea: Mesures de la pression artérielle rétinienne et de la tension céphalo-rachidienne dans quelques cas d'hypertension artérielle, Arch. d. mal. du cœur **17**:289-294, 1924.

33. Sobánski, J.: Das Wesen der tabischen Sehnervenatrophie und ihre Behandlung, Arch. f. Ophth. **135**:401-430, 1936.

It is of interest that the proponents of ophthalmodynamometry are of the opinion that dynamometric examinations are of equal, if not of appreciably greater, value than ophthalmoscopic examinations in the recognition and the differential diagnosis of diffuse vascular disease with hypertension. This point of view has been given further expression by workers who believe in the concept of solitary or cephalic hypertension. Bailliart stated in his earlier work that retinal hypertension may exist independently of systemic hypertension but that, since the circulation in the retina is known to reflect generally that in the brain, alterations in the retinal pressure imply the existence of like changes in the intracranial vascular pressure.

Espildora-Luque [34] recently has become an enthusiastic advocate of the value of ophthalmodynamometry in the clinical recognition of alterations in the level of cerebral vascular pressure. Suganuma and others previously had conducted somewhat similar investigations, and their conclusions agree in the main with the opinions expressed by Bailliart. Lauber [35] and Sobánski expressed the opinion that variations also may occur on the low side of the accepted normal values. They stated, however, that retinal hypotension is accompanied by, or due to, peripheral or systemic hypotension and that the diagnosis, prognosis and treatment of diseases of the optic nerve in particular may be greatly facilitated by the clinical appraisal of the relations of intraocular vascular pressures. Constantine,[36] in her study of the interrelation of the retinal and the systemic blood pressure of normal persons and of syphilitic patients, recently has reviewed the contributions of these authors. She not only was unable to confirm either their work or their theories but found that the differential between the retinal diastolic arteriolar pressure and the tonometric pressure was uniformly higher for patients with syphilis of the central nervous system either with or without optic atrophy than for normal persons. The brachial blood pressure also was slightly higher for the syphilitic patients than for the normal persons.

### CORRELATION

In general, then, it would appear with regard to either vascular micrometry or ophthalmodynamometry or both that on the basis of any single measurement no consistent relation of one or the other to the

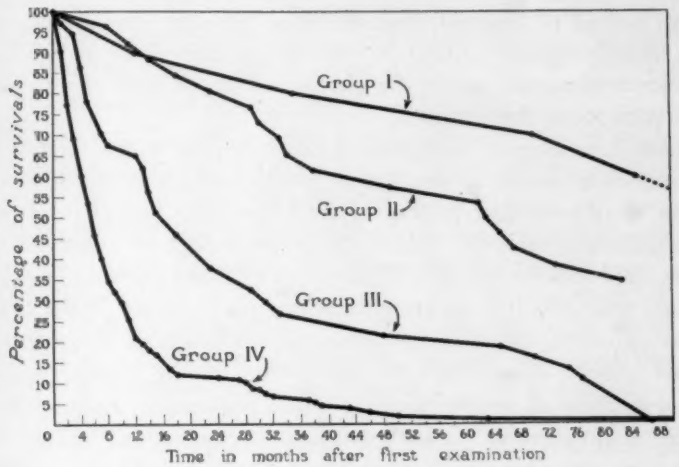
34. Espildora-Luque, C.: L'hypertension artérielle rétinienne solitaire, Tr. Internat. Ophth. Cong. (1937) **2**:156-189, 1938.

35. Lauber, H.: Der Einfluss niedrigen allgemeinen Blutdruckes auf den Verlauf von Sehnervenerkrankungen, Wien. klin. Wchnschr. **48**:1079-1081 (Aug. 30) 1935.

36. Constantine, E. F.: A Study of the Interrelationship of Retinal and Systemic Arterial Pressures and Intraocular Tension in Normal and Syphilitic Patients, Am. J. Ophth. **23**:436-445 (April) 1940.

brachial diastolic blood pressure and the grouping either of normal persons or of patients with pathologic elevation of the systemic blood pressure can be demonstrated. It is possible, however, on the basis of the mean values to confirm the soundness of the classification of Keith and of Wagener in grouping patients according to the severity of the hypertensive disease. The clinical information revealed by the ophthalmoscopic examination permits rather accurate classification of patients with diffuse arteriolar disease with hypertension according to the criteria of these authors.

The recent report of Keith, Wagener and Barker [37] gives emphasis to the clinical importance of a detailed examination of the fundi and, in particular, of the retinal arterioles, in conjunction with the objective




Survival curves for patients of the four hypertension groups. (From Keith, Wagener and Barker.[37])

findings revealed by the general physical examination, in appraisal of the clinical syndrome of essential hypertension. This study was based on the observation of 219 cases classified primarily into four groups according to the severity of the retinal changes and the associated pathologic elevation of the systemic blood pressure, together with the confirmatory objective findings. On the basis of their study these authors evolved actuarial survival curves (figure) which emphasize the significance of the original grouping, especially from the prognostic standpoint, since in groups 1 and 2, 10 to 12 per cent of the patients had died within

37. Keith, N. M.; Wagener, H. P., and Barker, N. W.: Some Different Types of Essential Hypertension: Their Course and Prognosis, Am. J. M. Sc. **197**:332-343 (March) 1939.

one year after the original examination. This is in marked contrast to the mortality of 35 per cent in group 3 and 79 per cent in group 4 during the same period. These curves demonstrate the serious prognostic significance of retinitis associated with hypertension. The greater severity of the hypertensive disease in groups 3 and 4 is suggested further by the finding in the present study that the mean values both for the retinal arteriolar measurements and for the ophthalmodynamometric readings showed greater deviations from the normal in groups 3 and 4 than in groups 1 and 2.

The most consistently abnormal values both in the retinal arteriolar measurements and in the ophthalmodynamometric readings were found in group 4. For the patients classified ophthalmoscopically in this group there was a mean decrease in caliber of almost 50 per cent and the mean ratio of retinal to brachial diastolic blood pressure rose from a normal of 40 to 68 per cent. Also, the percentage ratio of retinal to brachial diastolic pressure was above the established upper limit of normal of 55 for all patients in this group.

These facts suggest that there is some element in the type of hypertensive disease shown by patients in group 4 which produces more constant or more consistent vasoconstriction than does hypertension without retinitis and papilledema. Since the grade of organic arteriolar disease observed ophthalmoscopically is as severe in many patients belonging to groups 2 and 3 as it is in patients belonging to group 4, the arteriolar sclerosis in itself cannot account for the small size of the arterioles in the last group. The excessive narrowing of the arterioles and the relative increase of retinal diastolic blood pressure in group 4 must be due, then, to functional vasoconstriction. Whether this is caused by a simple increase in vasomotor tonicity or by the actual presence of vasopressor substance circulating in the blood it is impossible to say at present. However, the observations on patients with chronic glomerulonephritis suggest that a vasopressor substance may be the cause of this excessive narrowing of the arterioles, since it seems most logical on the basis of the work of Goldblatt [38] to assume that elevation of the blood pressure in chronic glomerulonephritis is due to elaboration of a vasopressor substance in the kidney.

## CONCLUSIONS

1. Clinically, there is little variation in the figures given by various authors for the caliber of the retinal arterioles of normal persons and of patients who have hypertension, although the values have been obtained with dissimilar apparatus.

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38. Goldblatt, H.: The Pathogenesis of Experimental Hypertension Produced by Renal Ischemia, J. A. M. A. **108**:675 (Feb. 20) 1937.

2. Ophthalmodynamometric readings vary rather widely no matter with which instrument they have been obtained. These variations are roughly proportional to the levels of the systemic blood pressure.

3. Relations between the caliber of the retinal arterioles and the retinal and the brachial diastolic blood pressure are not sufficiently consistent in individual cases to warrant the use of these values in the clinical classification of patients who have diffuse arteriolar disease with hypertension.

4. The mean values obtained for patients grouped according to the criteria of Keith and Wagener confirm the soundness of the classification of these authors from both the diagnostic and the prognostic standpoint.

5. Ophthalmoscopic examinations of normal persons and of hypertensive patients definitely are of greater clinical value in the individual case than is the determination of either the caliber of the retinal vessels or the blood pressure within them or both.

6. The individual measurements as well as the derived mean values confirm the view that there exists in the diffuse arteriolar disease with hypertension shown by groups 3 and 4 some factor, possibly actual intermittent or continuous angiospasm, superimposed on the already existing generalized increased arteriolar hypertonicity and sclerosis associated in most cases with elevation of the blood pressure.

## ABSTRACT OF DISCUSSION

DR. IRVING PUNTENNEY, Chicago: I congratulate Dr. Koch for his valuable contribution to the study of retinal vascular disease. It is of great importance to calibrate the retinal blood vessels and correlate changes in caliber with changes in the retinal and the brachial blood pressure.

The interpretation and the practical application of the findings are dependent on the role which the retinal arterioles play in diffuse arteriolar disease with hypertension. There are two theories which help explain their reactions. According to the first and commonly accepted one, the reduction in caliber is associated somehow with the cause of the hypertension. Dr. Koch believes that when his work is analyzed from this standpoint, ophthalmodynamometric measurements are not sufficiently consistent to be of great value, either in the individual case or in the classification of hypertensive patients.

The second theory presupposes that the changes in the retinal vessels are compensatory and secondary to the arterial hypertension. These reactions are all so complex that little is known concerning their obscure mechanisms, but it is known that under normal conditions an equilibrium is maintained in the retinal circulation. When this circulation is confronted with a prolonged elevation in arterial tension, a complex adjustment is needed for the maintenance of equilibrium. This adjustment must reduce the abnormally high retinal arterial pressure to the level of the normal venous pressure by the time the blood reaches the retinal veins. Since the venous pressure in a healthy eye must remain fairly constant, this resolves itself into the problem of increasing the resistance

in the arterioles and capillaries. Increased resistance in the arterioles can be accomplished by a reduction in their caliber; this lessens the proportion of resistance which the capillaries must provide. When this aspect of change in caliber is studied, retinal vascular disease can be investigated from a different standpoint. Such an investigation is certainly justified, since the etiology of hypertension is controversial.

The following slides, based on work being done in the Department of Ophthalmology at Northwestern University Medical School, will illustrate this second approach to Dr. Koch's problem. (Slides were shown.)

The first demonstrates the five groups into which Dr. Sanford Gifford and associates have divided patients with vascular disease of the fundi. This classification is similar to Wagener and Keith's. Group 1 represents retinal arteriolosclerosis, group 2 retinal arteriolosclerosis with retinopathy, group 3 diffuse retinal arteriolar constriction, group 4 diffuse retinal arteriolar constriction with retinopathy and group 5 diffuse retinal arteriolar constriction with neuroretinopathy.

The pictures reveal that the arteriovenous ratios of groups 1 and 2 are fairly comparable to normal ratios. However, the remaining groups show a diminution in caliber of the arterioles, with a ratio at times of 1:3 or less. This at once prompts an inquiry concerning the pressure relations which can change and still maintain an equilibrium, as in group 3. If this problem is to be investigated, it is necessary to correlate the fluctuations in pressure with the changes in caliber of the arterioles and find out how these relations influence the pressure level in the capillary bed and the veins.

In 1917 and 1918 Priestly-Smith published a series of articles based on experimental studies concerning the laws which control the passage of liquids through a tubular system contained within a closed space. This work enabled him to formulate certain principles. Two are extremely pertinent: 1. The fall in pressure in a tubular system is directly proportional to the resistance. 2. To find the relative resistance in different regions of a tubular system in which companion branches are of equal size, square the total cross section in each region and divide by the number of branches in that region; the products are inversely proportional to the resistance. These principles show that the pressure in the capillary bed can be lowered by a change in the arteriovenous ratio. The process reduces the resistance which the capillaries must exert and helps protect them from decompensation, the forerunner of edema and hemorrhage.

To summarize:

1. The venous pressure must remain fairly constant in a healthy eye. This compels the arterioles and capillaries to dissipate increased retinal blood pressure before the blood reaches the veins.

2. The fall in pressure is directly proportional to the resistance. The resistance in the arterioles can be increased by a narrowing of the lumens.

3. The retinal venous pressure becomes elevated when the arterioles and capillaries become decompensated. Decompensation is followed by edema and hemorrhage.

4. The retinal arterial and the retinal venous pressure must both be recorded if ophthalmodynamometry is to be of value.

5. Ophthalmodynamometry may prove to be of value in classifying patients in terms of retinal vascular decompensation.

DR. JAMES E. LEBENSOHN, Chicago: Dr. Koch's painstaking study confirms the accepted view that the proximate cause of essential hypertension is generalized arteriolar constriction. No confusion exists as to whether the change in caliber precedes or follows hypertension, since physiologists are now agreed that prolonged sustained hypertension can occur only as a consequence of increased peripheral resistance. The significance of the arterioles in the pathogenesis of essential hypertension is further accentuated by Koch's demonstration that as the caliber of the retinal arterioles is reduced the rise in retinal pressure does not parallel the rise in systemic pressure but is disproportionately higher. In this finding lies the principal clinical value of Bailliart's or Kukan's instrument.

Determinations of the blood pressure of the central retinal artery, as obtained by any ophthalmodynamometer yet devised, have only a comparative value. The figures secured by Duke-Elder from manometric measurements of the cat are systolic, 88½ and diastolic 64, and he expressed the opinion that for man the values are probably slightly higher. However, one may fairly assume that in any series of measurements of the retinal blood pressure made by the same observer the deviation from absolute values is approximately constant.

In a Paris thesis of 1828, Poisseuille first approached the problem of blood pressure through a hydrodynamic study of capillary tubes. By proving that the pressure rises in inverse proportion to the fourth power of the tube's radius, his work suggested that the systemic blood pressure can be greatly affected by a generalized slight change in the caliber of arterioles. Koch's determinations could not be expected to be in accord with Poisseuille's formula, chiefly because the measurements of caliber are of the branch arterioles while the variations in pressure are of the central artery. Nevertheless I found, as anticipated, that his figures do exhibit an apparent mathematical relation. The average retinal diastolic pressure for the normal persons and for groups 1, 2 and 3 are approximately inversely proportional to the square of the average arteriolar diameter. In group 4, however, the calculated pressure is notably higher than that observed (121, as opposed to 101), which is possibly symptomatic of an extremely decompensated condition of the retinal circulation.

In any attempt to correlate the clinical groupings of hypertensive patients with a dynamic analysis of the retinal circulation, the interplay of compensatory forces must be considered. The capillary pressure of the eye, according to Duke-Elder's estimates, varies from about 55 mm. of mercury on the arterial flank to 28 mm. at the venous border. As the tissue pressure is that of the intraocular tension, fluctuations of capillary pressure above and below these levels must normally occur to admit interchange of fluid. Dale and Richards showed that arteriolar constriction may be accompanied by capillary dilatation. An increase in venous caliber is similarly determined or passively follows. In the benign red hypertension of Volhard the ruddy complexion is due to dilated venules, while in malignant, or pale, hypertension there is capillary and venular constriction. It seems plausible that the state of circulatory compensation, which makes the difference between glaucoma simplex and congestive glaucoma, similarly decrees whether the course of hypertension is benign or malignant. Circulatory changes dominate the fundus picture of hypertensive disease. As Friedenwald and Wage-

ner have so well shown, the details of hypertensive retinopathy are not dependent on an imaginary toxin but mark the inevitable result of circulatory decompensation.

The classifications of Keith and of Gifford give the ophthalmologist a means of judging the probable longevity of his hypertensive patient and the clinical outcome. The interpretations are probably based on the following pathologic sequences: Primary arteriolar sclerosis, of mysterious origin, is irregular in its distribution and may affect the retina, brain or pancreas before the renal lesions are sufficiently advanced to induce hypertension. The hypertension then tends to develop insidiously, and death results from cardiac or cerebral involvement, complicated at times by diabetes. After experiments on the monkey, rabbit and dog, Goldblatt concluded that the production of sustained hypertension requires about 40 per cent constriction of the renal arteries. In cases of the fulminating type of hypertension adequate renal ischemia comes quickly. Angiospasm results, the blood pressure rises and, as the process advances, retinopathy becomes more and more evident until the impaired renal function finally precipitates a uremic death.

DR. FERDINAND L. P. KOCH, New York: Dr. Puntenney's admirable work never fails to engage my respect. It is painstakingly excellent, and, while I cannot always follow in detail, since the methods we employ in the classification of hypertensive disease differ to some extent, it would appear that essentially we are in agreement. I wish, however, that he had been able to show a curve for his fifth group.

This is not the time or the place, of course, for a discussion of the physiology of the intraocular vascular circulation. It appears likely that Dr. Puntenney's investigations will increase existing knowledge, particularly with regard to the capillary circulation, which has been stressed by Bailliart and his co-workers and especially by Fritz.

Dr. Lebensohn mentioned something I should like to emphasize: This study of mine was primarily a clinical investigation undertaken to determine, if possible, whether the ophthalmologist could or should rely on any single examination of a hypertensive patient in classifying the stage of the hypertensive disease.

# ALLERGIC DERMATITIS AND CONJUNCTIVITIS FROM PAREDRINE HYDROBROMIDE

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Allergic reactions to eye drops with resultant dermatitis and conjunctivitis are very common. They occur, for example, with atropine, which is the best known, and also with butyn, larocaine,[1] nupercaine [2] and other substances. As far as I know, no report has been made of an allergic reaction to paredrine hydrobromide.[3]

During the past two or three years paredrine hydrobromide has become fairly popular as a mydriatic, and some ophthalmologists use it in conjunction with homatropine for cycloplegia. As an aid in cycloplegia it is useless, in my opinion, but as a mydriatic, either alone or in conjunction with euphthalmine, it is excellent. I have used 1 per cent and 3 per cent paredrine hydrobromide for more than a thousand patients with no ill effects except in 1 case, which I am reporting here.

## REPORT OF A CASE

L. G., 64 years old, had bilateral nuclear sclerosis of the lenses, which decreased his vision to 20/100 in each eye. With glasses, vision of 20/40 in the right eye and of 20/30 in the left eye was obtained, but the patient had difficulty in doing his work, which was that of a tailor. By dilating his pupils with 1 per cent paredrine hydrobromide he was able to do his work much more easily. He used 1 drop in each eye three times daily from Sept. 7 to Nov. 26, 1940. On the latter date he started using 3 per cent paredrine hydrobromide, and after three days of using the 3 per cent solution he noticed that his eyelids and eyes became red. Itching and tearing became pronounced. He returned to the clinic, where a typical picture of conjunctivitis and dermatitis venenata was seen. The upper and lower lids of both eyes were very red, scaly and dry; the outer angles were cracked, and the conjunctivas of the lids and globes were congested and markedly injected. Instillation of 2 drops of a 1:1,000 solution of epinephrine hydrochloride in each

From the clinic of Dr. N. Fletcher, the Manhattan Eye, Ear and Throat Hospital.

1. Theodore, F.: Hypersensitivity to Larocaine, Arch. Ophth. **20**:474 (Sept.) 1938.

2. Perera, C. A.: Ocular Sensitivity to Nupercaine, Arch. Ophth. **24**:344 (Aug.) 1940.

3. Paredrine hydrobromide is *p*-hydroxy-d-methylphenethylamine hydrobromide. The preparation used was paredrine hydrobromide ophthalmic (Smith, Kline and French), a solution of the essential compound.

eye and application of cotton soaked in the same solution to the eyelids for a few minutes gave relief from the itching and blanched the lids and the conjunctivas. The patient was advised to use ice cold boric acid compresses and zinc oxide ointment to the lids. He reported to the clinic in one week and stated that his eyes had become entirely comfortable three days after the aforementioned treatment was begun. Examination showed no evidence of dermatitis or of conjunctival injection. He was requested to use the 3 per cent paredrine hydrobromide again in both eyes twice daily. He returned two days later with an exacerbation of the dermatitis and the conjunctivitis, which he said had started an hour after the second drop was instilled into each eye, and of course he used no more drops thereafter. At this time a 1 per cent solution was ordered, and after use of 1 drop in each eye the same reaction occurred in both eyes.

It is common knowledge that an allergic status can develop after an allergen has been used for a long time, even though there has been no allergic manifestation during that time. In ocular work this is often seen in patients who have used 1 per cent atropine sulfate solution (or stronger solutions) for a considerable time before becoming allergic. When the allergy does develop it is sufficient to preclude the use of even the weakest solutions of atropine, so that scopolamine must be substituted. It is of interest to note that at the beginning the patient manifested no reaction to the 1 per cent solution of paredrine hydrobromide. However, after using a 3 per cent solution for a very short time (only three days) a marked allergic reaction ensued. This allergic status became sufficiently strong to provoke a reaction after the use of 1 drop of the 1 per cent solution.

# ACUTE FOLLICULAR CONJUNCTIVITIS RESEMBLING BÉAL'S TYPE

## REPORT OF TWO CASES, WITH A SHORT REVIEW OF THE LITERATURE

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In this communication I am recording my observations on 2 cases of acute follicular conjunctivitis of a variety which closely resembled Béal's type but differed from it in slight details. The occurrence of this type of follicular conjunctivitis is sufficiently rare to justify my presentation of these 2 cases, together with a brief review of the literature.

The question of the etiology, symptomatology and bacteriologic characteristics of follicular conjunctivitis has long engaged the attention of ophthalmologists all over the world. Suśruta,[1] in the prehistoric age, was the first to describe follicular conjunctivitis as an inflammatory disease of the eyelid. He differentiated between two types of the disease, namely, *pōthaki* (follicular conjunctivitis) and *lagana* (papillary conjunctivitis).

Modern ophthalmologists have studied the disease in all its aspects. The common type of follicular conjunctivitis as described in textbooks is characterized by the presence of small, round or oval, translucent bodies up to 2 mm. in diameter, situated mostly in the inferior fornix conjunctivae. They are generally raised above the surface and are often grouped in parallel rows; they consist of aggregations of lymphocytes, which form follicles in the subepithelial adenoid layer.[2]

Follicular conjunctivitis most frequently affects young persons, especially students in public and boarding schools. In most children the disease exists in latent form, so that despite the presence of a considerable number of follicles the conjunctiva is pale and causes no discomfort, and the disease is first discovered on routine medical examination. In some cases the folliculitis remains unchanged for years. In other cases the disease is acute; inflammation of the conjunctiva and the symptoms and signs of severe catarrhal ophthalmia are present, with

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From the Suśruta Clinic.

1. Suśruta: Suśruta Samhitā, with Dallana Acharya's commentary, edited by Yādava Sharma, ed. 2, Bombay, Nirnaya-Sagar Press, 1931. Bidyādhar, N. K.: Suśruta and His Ophthalmic Operations, Arch. Ophth. **22**:550 (Oct.) 1939.

2. Parsons, J. H.: Diseases of the Eye, ed. 7, London, J. & A. Churchill, Ltd., 1934, pp. 171-172.

the attendant development of numerous follicles.[3] In addition to the chronic and the acute form of the disease, there have been numerous cases reported of a type of follicular conjunctivitis in which follicles appear and there are slight irritation and inflammation of the conjunctiva, accompanied with correspondingly mild symptoms.

Apart from the common textbook types of follicular conjunctivitis, which are encountered all over the world, both in tropical and in non-tropical climates, research workers in the field of ophthalmology have established as clinical entities some special types of this disease. Two well defined types have been identified clinically and bacteriologically, namely, swimming pool conjunctivitis and Béal's type of follicular conjunctivitis.

Representative investigations are those of Fehr,[4] Paderstein,[5] Huntemüller and Paderstein,[6] Stargardt,[7] Heymann,[8] Lindner,[9] Wolfrum,[10] Fritsch, Hofstätter and Lindner,[11] Engelking,[12] Hamburger,[13] Thygeson,[14] Aust,[15] Rohrschneider,[16] Fodor[17] and Morax.[18] The classic works of Béal[19] and Morax[20] and the investigations of Dusseldorp[21] and Thygeson[22] have helped to establish the clinical entity of Béal's type

3. Fuchs, E.: Diseases of the Eye, ed. 10, translated by E. V. L. Brown, Philadelphia, J. B. Lippincott Company, 1933, p. 62.

4. Fehr: Berl. klin. Wchnschr. **37**:10, 1900.

5. Paderstein, R.: Klin. Monatsbl. f. Augenh. **51**:840, 1913; **74**:634, 1925.

6. Huntemüller and Paderstein, R.: Deutsche med. Wchnschr. **39**:63, 1913.

7. Stargardt, K.: Arch. f. Ophth. **69**:525, 1909.

8. Heymann, B.: Deutsche med. Wchnschr. **35**:1692, 1909.

9. Lindner, K.: Gonoblenorrheoa, Einschlussblenorrhoe und Trachom, Arch. f. Ophth. **76**:559, 1910; **78**:345, 1911; **122**:391, 1929; **133**:479, 1935.

10. Wolfrum: Ber. ü d. Versamml. d. ophth. Gesellsch. **60**:207, 1910.

11. Fritsch, H.; Hofstätter, A., and Lindner, K.: Arch. f. Ophth. **76**:36 and 661, 1910.

12. Engelking, E.: Klin. Monatsbl. f. Augenh. **66**:764, 1921.

13. Hamburger, F.: Arch. f. Ophth. **133**:90, 1934.

14. Thygeson, P.: Am. J. Ophth. **15**:293, 1932; **16**:409, 1933; **17**:787 and 1019, 1934; The Nature of the Elementary and Initial Bodies of Trachoma, Arch. Ophth. **12**:307 (Sept.) 1934.

15. Aust, O.: Ztschr. f. Augenh. **58**:450, 1926; **62**:187, 1927; Arch. f. Ophth. **123**:93, 1930.

16. Rohrschneider, W.: Klin. Monatsbl. f. Augenh. **76**:619, 1926.

17. Fodor, G.: Ztschr. f. Augenh. **63**:150, 1927.

18. Morax, V.: Arch. internat. du trachom **6**:90, 1929; **7**:2, 1930; **10**:190, 1933; Les conjunctivites folliculaires, Paris, Masson & Cie, 1933.

19. Béal, R.: Ann. d'ocul. **137**:1, 1907.

20. Morax, V.: Ann. d'ocul. **159**:281, 1922; footnote 18.

21. Dusseldorp, M.: Tracoma, Buenos Aires, 1927.

22. Thygeson, P.: Acute Follicular Conjunctivitis, Béal's Type, Arch. Ophth. **13**:853 (May) 1935; Am. J. Ophth. **21**:1017, 1938.

of follicular conjunctivitis. The work of Bhaduri [23] in India has stimulated interest in the detection of the various types of follicular conjunctivitis among Indian patients with diseases of the conjunctiva.

The follicular conjunctivitis in the 2 cases which I am reporting is a variant of Béal's type.

## REPORT OF CASES

CASE 1.—A healthy man aged about 19 years reported to the Suśruta clinic in October 1940 for the treatment of what he called "irritation of the eyelid and persistent reddening of the eye of sudden onset."

*History.*—According to the patient's history, the inflammation of the right eye, the first affected, had started about five days before with a feeling of irritation and heaviness and a gritty sensation in the lids. The symptoms which annoyed him most were the edema of the eyelids, the feeling of irritation and the sensation that a foreign body was present and the persistent redness of the eyes. There was practically no discharge. He applied the usual home medicines, that is, antiseptic and astringent eyewashes, but the signs and symptoms, including the redness and considerable hyperemia, persisted and gradually spread to the other eye, at which stage the patient came under my care. The patient stated that he had had a similar attack the previous year.

*Physical Examination.*—Examination revealed edema of the right eyelids, more pronounced in the lower than the upper lid, and nontender almost equal, bilateral enlargement of the preauricular lymph glands, that on the right being more shotty than the one on the left. No tenderness was elicited by applying pressure on the preauricular region, and the glands were freely movable under the skin. The time of onset of the swelling of the glands with respect to the appearance of the inflammatory symptoms in the eyes could not be determined in this case, as by the time the patient came under observation in the clinic the glands were already in evidence.

Examination showed that the peripheral portion of the bulbar conjunctiva was most injected, the medial portion being much less affected. The vascular congestion was most marked in the fornices and the palpebral portion. The fornices appeared succulent and liver colored and were studded with hypertrophied follicles, which were situated close together in irregular rows and were most numerous in the lower palpebral conjunctiva.

Examination of the left eye revealed changes similar to those noticed in the right, though of a comparatively lesser degree.

None of the members of the patient's family was reported to have the disease, although he had mixed freely among them.

*Course.*—The disease attained its maximum severity between the fifth and the seventh day, from which time the inflammatory condition began to subside, till by about the thirteenth day complete resolution became manifest. The normal condition of the eye was restored by the fourteenth day, the enlargement of the preauricular glands disappearing in the meantime.

*Laboratory Examination.*—For the purposes of establishing the diagnosis, material was taken from both eyes for microscopic examination and for culture. Examination of the smears showed large numbers of mononuclear cells, there being more cells in the material from the eye which was affected first. There were no inclusion bodies. Culture gave negative results.

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23. Bhaduri, B. N.: Proc. All-India Ophth. Soc. **6**:59, 1938.

Examination of the blood revealed lymphocytosis and eosinophilia of a moderate degree. The patient did not have any infection of the skin or intestines at the time which might have caused the eosinophilia. I have been making a study of the blood in cases of conjunctivitis to see whether the blood picture would help to differentiate the various forms of the disease. At present nothing can be said regarding the significance of the observations on the blood made in 1 or 2 isolated cases. Before long, I hope to present the results of a complete study of this subject.

*Therapy.*—In this case the disease responded satisfactorily to simple therapy. Irrigation of the eyes with a physiologic solution of sodium chloride, hot compresses of lotion of berberis extract and eyedrops of boroberberine lotion were used regularly. The composition of the boroberberine lotion which I employed is as follows:

| | Gm. or Cc. |
|---|---|
| Boric acid | 0.32 to 0.45 |
| Berberine sulfate | 0.16 to 0.32 |
| Solution of epinephrine hydrochloride | 0.18 |
| Chlorobutanol | 0.16 to 0.32 |
| Water To make | 30 |

In my practice I have observed cases of typical bilateral acute follicular conjunctivitis of sudden onset which runs a definite course, and is characterized by scanty or no discharge, benign clinical symptoms, preauricular adenopathy and complete cure, with good response to simple therapy. This type of conjunctivitis has occurred in children whose ages ranged between 12 and 15 years and also in adults up to the age of 19 or 20 years. The disease in such cases differs clinically and bacteriologically from acute catarrhal conjunctivitis and the other types of follicular conjunctivitis commonly known as "school folliculosis."

In case 2, the report of which follows, the patient had acute follicular conjunctivitis which affected both eyes simultaneously.

CASE 2.—A boy about 12 years of age was brought to the Suśruta Clinic in August 1939. His health was moderately good. He had had recurrent attacks of inflammation of the conjunctiva in the past, which had so upset the parents that this time the boy was brought under treatment the very day the inflammation of the eye set in. This afforded a good chance of observing the course of the disease from the preliminary stage to the period of resolution. Almost simultaneously both eyes became inflamed. From the second day on the preauricular glands on both sides were palpably enlarged, the enlargement being most marked on the fourth day. They remained enlarged till the end of the second week, after which they began to disappear with the resolution of the conjunctival inflammation and hyperemia.

Edema of a moderate degree appeared almost simultaneously in the lids of both eyes. The peripheral portions of the bulbar conjunctivas were injected. The vascular congestion was intense in the fornices and in the palpebral portions of both eyes. The fornices were thick and bright red and were covered with pearl-like follicles, most numerous in the lower palpebral conjunctivas.

Symptoms of the disease lasted for over two weeks; there was complete resolution by about the seventeenth day.

The therapy adopted in this case was the same as that used in case 1, with the addition that a diet rich in vitamins, consisting of such foods as milk and fruits, was prescribed.

Examination of the smears of material from both eyes showed many mononuclear cells but no inclusion bodies. Culture of material from the eyes gave negative results. Examination of the blood showed lymphocytosis and mild eosinophilia.

## COMMENT

In case 1, that of a 19 year old youth, there was acute bilateral follicular conjunctivitis of sudden onset, which was characterized by benign clinical symptoms, that is, the appearance of pearl-like follicles accompanied by lower palpebral hyperemia and preauricular adenopathy, and complete resolution and cure. The left eye was affected after the right; the duration of the disease was about two weeks. In case 2, the symptoms appeared almost simultaneously in the two eyes; the enlargement of the preauricular glands was noticed on the second day; the disease lasted more than two weeks. The patient was a 12 year old boy. In both cases there was practically no discharge and examination of smears of material from the eyes showed large numbers of mononuclear cells but no inclusion bodies. Culture gave negative results. Examination of the blood showed moderate lymphocytosis and eosinophilia.

The history and the signs and symptoms coincide with those of Béal's type of acute follicular conjunctivitis. Béal's type of conjunctivitis usually attacks adults, but in the 2 cases reported the patients were 19 and 12 years old, respectively. Another difference in detail was that in the first case the disease affected the eyes in sequence, whereas in the second case the symptoms appeared simultaneously in the two eyes.

In the differential diagnosis swimming pool conjunctivitis and the type of conjunctivitis follicularis generally known as school folliculosis are to be considered.

Swimming pood conjunctivitis is a type of follicular conjunctivitis caused by a filtrable virus. It has a slow onset and runs a leisurely clinical course and is characterized by considerable hyperemia, slight discharge and preauricular adenopathy ending in resolution.[24] The intracellular inclusion bodies, which can be seen in the smears of conjunctival epithelium, have been incriminated as the causative infective agent. In my cases, the typical history, the symptoms and signs and the presence of large numbers of mononuclear cells in the smears and the absence of inclusion bodies clinch the diagnosis of Béal's type of conjunctivitis and eliminate the possibility that the disease was swimming pool conjunctivitis.

24. Duke-Elder, W. S.: Diseases of the Conjunctiva, in Tidy, H. L., and Short, A. R.: Medical Annual, London, Butterworth & Co., Ltd., 1936, vol. 54, p. 137.

As for school folliculosis, which is prevalent in the tropics, especially among persons of the age of the patient in case 2, the early appearance and the complete resolution of the follicles, the presence of large numbers of mononuclear cells in the smears and above all the negative bacteriologic findings exclude the possibility that the conjunctivitis was of that type.

## REVIEW OF THE LITERATURE

In 1907 Béal,[19] working under Morax, observed a special type of acute follicular conjunctivitis, which was characterized by rapid onset, early appearance of follicles, preauricular adenopathy, a benign clinical course and complete resolution within a short period. Morax [20] named this disease Béal's type of follicular conjunctivitis, after his pupil. Since then the disease has been studied closely by several investigators. It was Dusseldorp [21] who made a comprehensive slit lamp study of the disease in 1927. In 1935 Thygeson [22] observed an epidemic of this disease among the university students of Iowa. Again in 1938, he reported on 13 patients with this disease treated at the Vanderbilt clinic. Bhaduri,[23] in India, was the first to report a case of Béal's type of follicular conjunctivitis in 1938.

There seems to have been genuine scientific interest in the clinical and etiologic study of swimming pool conjunctivitis ever since 1900, when Fehr [4] established this conjunctival disease as a clinical entity. To Paderstein [5] goes the credit for having discovered, in 1913, that in cases of the disease there are intracellular inclusion bodies in the epithelium similar to those described by Halberstaedter and von Prowazek.[25] In the same year Huntemüller and Paderstein by inoculating a monkey's conjunctiva with conjunctival epithelial material produced a similar type of follicular conjunctivitis experimentally. A series of interesting investigations have been carried out by various observers in order to ascertain the nature and the specificity of such inclusion bodies.

Inclusion bodies similar to those of Paderstein were discovered in cases of ophthalmia neonatorum largely through the investigations of Stargardt [7] (1909) and Heymann [8] (1909), while Lindner [9] (1910) observed the presence of similar inclusion bodies in cases of a type of ophthalmia in which neither gonococci nor other pathogenic organisms were detected. This disease, which he called inclusion blennorrhea, could be transferred to monkeys through inoculation of the conjunctival material obtained for smears. This study was pursued further by Wolfrum [10] (1910), who was able to produce a benign type of trachoma by inoculating an adult with material taken from the eyes of an infant with inclusion blennorrhea.

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25. Halberstaedter, K., and von Prowazek, S.: Deutsche med. Wchnschr. **33**: 1285, 1907.

Similar inclusion bodies in material from the urethra of patients with mild nongonococcic urethritis were detected by Fritsch, Hofstätter and Lindner [11] (1910). Follicular conjunctivitis was produced by injecting such material into the conjunctiva of monkeys. Arguing on the strength of these experimental findings, Lindner [9] (1911) evolved the theory that the inclusion blennorrhea of infants was a "genital trachoma," an attenuated benign form of the disease contracted through contact with the urethral discharge of the mother; but this theory was soon after refuted by Löhlein [26] (1913), Gebb [27] (1914) and others. Engelking [12] (1921), who had corroborated Paderstein's discovery of inclusion bodies in cases of swimming pool conjunctivitis, took up the knotty problem of classification and termed the disease a genital infection. In this connection it is important to note that two independent observers, Hamburger [13] (1934) and Thygeson [14] (1934), found inclusion bodies in material from the urethras of the members of both sexes who had the disease and also in material from the vaginas of some patients' mothers who had some vaginal discharge.

Lindner [9] (1929, 1935) and Aust [15] (1926, 1927, 1930) revived the old theory of attenuated genital trachoma after the latter author had observed a case of inclusion blennorrhea in a baby born of a woman with swimming pool conjunctivitis.

In "Diseases of the Conjunctiva" by Duke-Elder [28] this passage appears:

> These, and confirmatory observations and experiments of Morax (1933) and others, leave no doubt that the two types of conjunctivitis are the same—inclusion blennorrhoea of the new born and swimming-bath conjunctivitis, for it has been amply demonstrated that inoculation of the adult with the conjunctival secretion of the infant produces a condition identical with swimming-bath conjunctivitis, and inoculation of the monkey with either produces a follicular conjunctivitis clinically and experimentally identical.

That the infective agent is a filtrable virus has been fully demonstrated, as inoculations have been successfully performed with the filtrate obtained by passing emulsified conjunctival scrapings through the finest Berkefeld filter.

It is further interesting to note that inclusion bodies have not been found in every case of swimming pool conjunctivitis (Rohrschneider,[16] 1926; Fodor,[17] 1927; Aust,[15] 1930, and Morax,[18] 1933), while such inclusion bodies have often been detected in cases of infections not of that type (Morax,[18] 1933, and Pillat,[29] 1926). Lindner (1935) there-

26. Löhlein, W.: Arch. f. Ophth. **84**:554, 1913.
27. Gebb, H.: Ztschr. f. Augenh. **31**:475, 1914.
28. Duke-Elder,[24] p. 138.
29. Pillat, A.: Klin. Monatsbl. f. Augenh. **58**:426, 1926; **59**:316, 1926.

fore postulated two varieties of swimming pool conjunctivitis—one in which inclusion bodies were present and one in which they were not; but since in practice no clinical differentiation is possible, this postulation remains untenable owing to lack of experimental evidence.

The controversies raging over the problem of inclusion bodies have not yet been settled, but Braley [30] has done a valuable service in the matter of clarifying the subject of the epithelial inclusion bodies of the conjunctiva. Further research to illuminate the problem is indicated.

## SUMMARY AND CONCLUSION

Two typical cases of a comparatively rare variety of acute follicular conjunctivitis, resembling Béal's type, have been reported.

The special feature of these 2 cases were: sudden onset, benign clinical symptoms, characterized by the early appearance of the follicles, scanty discharge and preauricular adenopathy, prompt response to simple therapy and rapid and complete resolution. Examination of smears showed large numbers of mononuclear cells. Inclusion bodies were absent, and culture gave negative results. Examination of the blood in both cases showed lymphocytosis and moderate eosinophilia.

Béal's conjunctivitis generally attacks adults; the patients in these 2 cases were 19 and 12 years old. In 1 case, the inflammatory symptoms appeared in sequence in the eyes, while in the other the symptoms appeared almost simultaneously in the two eyes. The duration of the disease was two weeks in 1 case and more than two weeks in the other.

The literature on Béal's type of conjunctivitis and on swimming pool conjunctivitis has been briefly reviewed.

In reviewing the available literature, I found that only 1 case of Béal's type of follicular conjunctivitis has so far been reported from India, by Bhaduri.[23] My presentation of these 2 cases therefore furnishes the second such report.

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30. Braley, A.: Intracellular Bodies of the Conjunctival Epithelial Cells, Arch. Ophth. **24**:681 (Oct.) 1940.

# KAYSER-FLEISCHER RING ASSOCIATED WITH HEPATOLENTICULAR DEGENERATION

## REPORT OF SIX CASES

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Hepatolenticular degeneration was defined as an entity by Wilson [1] in 1912. However, typical examples had been described under other names by Frerichs [2] in 1860 and by Gowers [3] in 1888. The corneal ring was first described by Kayser [4] in 1902, in a case in which the diagnosis was multiple sclerosis. Fleischer [5] reported the ring in 1903 in a case in which the condition was called pseudosclerosis. Later it was appreciated that the Kayser-Fleischer ring is pathognomonic of hepatolenticular degeneration. The neurologic signs of this disease are not always diagnostic. The hepatic cirrhosis usually causes no symptoms; so the diagnosis of hepatolenticular degeneration often depends on finding the Kayser-Fleischer ring in the cornea.

Patients with this condition show a remarkable similarity in their family history and in the development of their symptoms. Consanguinity of the parents is often disclosed. The childhood and early development of the patients are usually normal, though many report having had acute hepatitis and ascites before the age of 10 years. At about the age of 15 the nervous signs become manifest and the Kayser-Fleischer ring is found. The patients usually die in their twenties.

### PATHOLOGIC PICTURE

Thirty autopsies have been reported, all demonstrating atrophic cirrhosis of the liver, of the hobnail variety. In all, the liver was observed

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From the Ophthalmologic Service of Dr. Robert K. Lambert, Montefiore Hospital for Chronic Diseases.

1. Wilson, S. A. K.: Progressive Lenticular Degeneration: A Familiar Nervous Disease Associated with Cirrhosis of the Liver, Brain **34**:295, 1912.

2. Frerichs, F. T.: A Clinical Treatise on Diseases of the Liver, translated by C. Murchison, London, New Sydenham Society, 1861, vol. 2, p. 60.

3. Gowers, W. R.: Manual of Diseases of the Nervous System, London, J. & A. Churchill, 1888, vol. 2, p. 656.

4. Kayser, B.: Ueber einen Fall von angeborener grünlicher Verfärbung der Kornea, Klin. Monatsbl. f. Augenh. **40**:22, 1902.

5. Fleischer, B.: Zwei weitere Fälle von grünlicher Verfärbung der Kornea, Klin. Monatsbl. f. Augenh. **41**:489, 1903.

to be small and hard, with nodules of normal tissue separated by cirrhotic bands, and microscopic studies showed normal areas interspersed with areas of fatty degeneration and necrosis, with some regeneration.

Bilateral degeneration of the lenticular nucleus is characteristic. There are necrosis, liquefaction and glial proliferation, particularly in the corpus striatum, the region of the putamen, the globus pallidus, the thalamus opticus and the nucleus dentatus. The disease affects the brain more extensively than was previously thought and is not confined to the lenticular nucleus. Large areas of the brain are often degenerated, with loss of ganglion cells and atrophy. The only individual characteristic of the degeneration is the presence of Alzheimer's giant cells.

### SYMPTOMS

The patients have a remarkable degree of euphoria. This seems accentuated by frequent spastic smiles and spells of emotionalism. Speech is impaired and may become unintelligible. A marked intention tremor develops. The limbs become rigid and the movements awkward, often of the cogwheel type. Some have peculiar wing-beating motions (so-called *Pflügelschagen*), which were studied by Goodhart and Balser.[6] Mental deterioration occurs in most cases. Periods of fever of unexplained origin recur, lasting from a few days to weeks. There is reason to believe that the fever originates in the central nervous system. Physical and mental degeneration progress until death.

### AGE INCIDENCE; DURATION

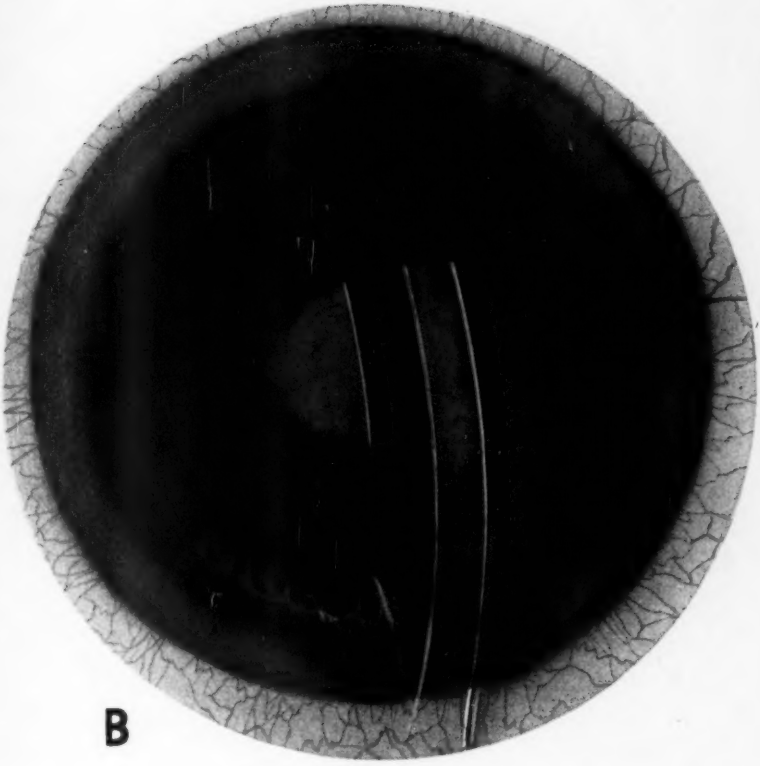
The youngest patient in this series was 8 years old, and the oldest, 68. By far the largest number showed their first symptoms between the ages of 15 and 20.

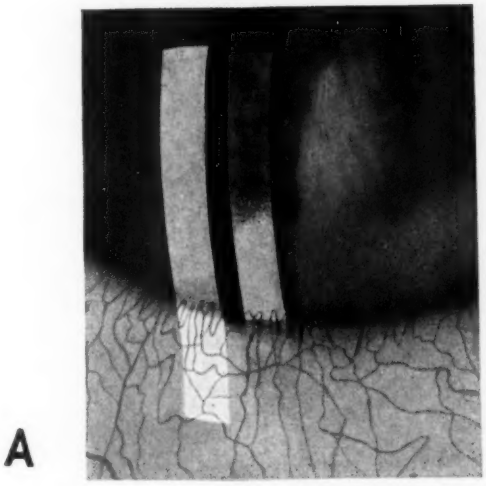
The acute conditions with fever last four to thirteen months. The chronic conditions range in duration from two and one-half to seven years. A case has been reported in which there was a duration of forty-three years.

### APPEARANCE OF KAYSER-FLEISCHER RING

The Kayser-Fleischer ring in the cornea makes an interesting picture (see *A* in accompanying illustration). With ordinary illumination it seems only as if the limbus were outlined by a dark, almost black, circle. With stronger, focal illumination, the ring in the cornea is green-brown. With the slit lamp it is a brilliant golden brown, resembling the tint of a maple leaf in autumn. The ring is located on the posterior surface of the cornea. The outer border begins sharply at the limbus and extends

6. Goodhart, S. P., and Balser, B. H.: Somatotropic Localization in the Extrapyramidal System, Arch. Neurol. & Psychiat. **39**:1043 (May) 1938.




*A*, Kayser-Fleischer corneal ring in a case of hepatolenticular degeneration. *B*, sunflower opacity on the lens and Kayser-Fleischer ring in the cornea.

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inward 1 to 3 mm. The outer part is densely pigmented, with some mottling. The inner part is composed of more discrete granules of pigment.

The inner border has a transition zone of 2 to 3 mm. between it and the clear cornea. This zone is tinted a delicate blue, with slight mottling. I found this in all the cases I observed, though it is not generally described. This blue zone has added interest, as its color and quality resemble those of the lens opacity found in 1 of my cases and described by others as the sunflower opacity. Whether the blue zone is a second type of pigment or the same as the rest of the Kayser-Fleischer ring in a thinner layer I could not determine. I am rather inclined to believe that it is a thinner layer and therefore has a different optical effect.

The ring is usually noted at the onset of the nervous symptoms. At first it is a broken ring with delicate pigmentation, visible only with the slit lamp and gradually becoming more pronounced; later it is easily seen with the naked eye.

Microscopic sections of eyes with the Kayser-Fleischer ring were studied by Hall,[7] Vogt,[8] Jess[9] and Rohrschneider.[10] All agreed that the ring is due to pigment deposited in the inner portion of Descemet's membrane. The outer part of Descemet's membrane may be unaffected. The endothelium is clear.

Determination of the chemical nature of this pigment has presented a difficult problem, which despite much research has been only partially solved. Rumpel[11] found silver and copper in the liver and kidneys and expressed the belief that the pigment is due to silver. Vogt[12] concluded that silver is the basis of the pigmentation.

Copper has also been considered as a possible cause, particularly since increased amounts of copper have been found in the internal organs in some cases. Another reason is that an additional finding in some cases

7. Hall, H. C.: La dégénérescence hépatolenticulaire. Maladie de Wilson. Pseudosclérose, Paris, Masson & Cie, 1921.

8. Vogt, A.: Atlas der Spaltlampenmikroskopie des lebenden Auges, Berlin, Julius Springer, 1930, vol. 1.

9. Jess, A.: Die Pigmenteinlagerung der Linse bei Pseudosklerose in histologischen Schnitt, Klin. Monatsbl. f. Augenh. **79**:145, 1927.

10. Rohrschneider, W.: Untersuchung über den in der Hornhaut des Auges bei der hepatolentikulären Degeneration abgelagerten Farbstoff, Arch. f. Augenh. **108**:391, 1934.

11. Rumpel, A.: Ueber das Wesen und die Bedeutung der Leberveränderungen und der Pigmentierungen bei den damit verleidenen Fallen von Pseudosklerose, zugleich ein Beitrag zur Lehre von der Pseudosklerose, Ztschr. f. Nervenh. **49**: 54, 1913.

12. Vogt, A.: Kupfer und Silber aufgespeichert in Auge, Leber, Milz und Nieren als Symptom der Pseudosklerose, Klin. Monatsbl. f. Augenh. **83**:417, 1929.

of hepatolenticular degeneration is a bluish opacity on the anterior capsule of the lens. This resembles the Purtscher pseudocataract, which is pathognomonic of copper in the eye.

Hall [7] and Fleischer [13] made spectrographic studies which proved that the pigment is not silver but probably a derivative of hemoglobin. Siemerling and Oloff [14] found no silver or copper in the pigment. Kubik [15] made a spectroscopic study of the pigment and found it similar to urobilin but found no lines for silver or copper. Other spectroscopic studies, by Gerlach and Rohrschneider,[16] Fleischer and Gerlach [17] and Rohrschneider,[10] confirmed the absence of silver and determined the presence of physiologic quantities of copper, which apparently were not related to the Kayser-Fleischer ring.

### LENS OPACITY

Six cases have been described in which, in addition to the Kayser-Fleischer ring, there was an opacity on the anterior capsule of the lens. This was seen in both eyes in 1 of my cases (*B* in illustration). The opacity was about 4 mm. wide and occupied the pupillary portion of the lens, while the periphery was clear. Some patients had extensions of the opacity in a petal-like arrangement (sunflower cataract). Jess [9] examined microscopically an eye with this type of opacity. He found pigment on the anterior lens capsule but no opacity in the lens itself. This type of opacity is not a cataract, and the name sunflower cataract is a misnomer. It is a pigment deposit on the lens capsule. For some unknown reason the pigmentation is largely confined to the central pupillary zone. Under the slit lamp the opacity in my case was an extremely thin layer of pigment on the anterior capsule, tinted a delicate blue. The surface was granular and the edges fuzzy. Instances of these opacities have been reported by Siemerling and Oloff,[14] Vogt,[12] Hessberg [18] and Kubik.[15] The pigment of the lens and cornea is probably transmitted through the aqueous.

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13. Fleischer, B.: Ueber den Haemosiderinring in Hornhautepithel bei Keratokonus und Wilsonscher Krankheit, Klin. Monatsbl. f. Augenh. **68**:47, 1922.

14. Siemerling, E., and Oloff, H.: Pseudosklerose mit Cornealring und doppelseitiger Scheinkatarakt, Klin. Wchnschr. **1**:1087, 1922.

15. Kubik, J.: Ueber das Substrat des Pseudosklerosenringes, Klin. Monatsbl. f. Augenh. **84**:478, 1930.

16. Gerlach, W., and Rohrschneider, W.: Besteht das Pigment des Kayser-Fleischerschen Hornhautringes aus Silber? Klin. Wchnschr. **13**:48, 1934.

17. Fleischer, B., and Gerlach, W.: Zur Frage der Silberpigmentierung des Kayser-Fleischerschen Hornhautringes, Klin. Wchnschr. **13**:255, 1934.

18. Hessberg, R.: Klinische Nachweis und Analyse des Kayser-Fleischerschen Pigmentringes der Pseudosklerose in der Linse, Klin. Monatsbl. f. Augenh. **75**:12, 1925.

### INCIDENCE OF KAYSER-FLEISCHER RING

Hall collected 61 cases of hepatolenticular degeneration, with the Kayser-Fleischer ring in 21. Probably more examples of the Kayser-Fleischer ring would have been found with careful slit lamp study. Goldblach [19] collected 89 cases; the Kayser-Fleischer ring was reported as present in all.

In all of the 6 cases which I observed, as well as in 2 others in which I reviewed the charts at Montefiore Hospital, the Kayser-Fleischer ring was present bilaterally.

### CORNEAL RINGS WITHOUT HEPATOLENTICULAR DEGENERATION

A few reports have been published describing a corneal ring resembling the Kayser-Fleischer ring in association with conditions other than hepatolenticular degeneration. Holzer [20] reported a case in which encephalitis was present, with transient lenticular symptoms. Wimmer [21] reported on a patient with the Kayser-Fleischer ring who came to autopsy. There was extrapyramidal motor involvement, but there were no hepatic lesions. Jess [22] reported 4 cases of copper impregnation in the eye with a corneal ring resembling the Kayser-Fleischer ring. Gunther [23] reported traces of Kayser-Fleischer ring in a case of hemichorea with chronic nephritis.

### OTHER OCULAR DATA

In the cases observed by me the ocular movements were jerky and fixation was poorly sustained. After the patients had looked at a light for a fraction of a minute, they showed coarse nystagmoid movements and their eyes wandered off. I saw them many times before I could complete the examination. Vision was good in all the cases, and the fields of vision were normal. The fundi showed no abnormality.

Fleischer [13] and Metzger [24] each reported a case in which there was associated night blindness. Pillat [25] described the case of a Chinese

19. Goldblach, L. J.: Kayser-Fleischer Ring: Wilson's Disease, Am. J. Ophth. **21**:1118, 1938.

20. Holzer, P.: Der amyostatische Symptomcomplex bei Encephalitis epidemica, Berl. klin. Wchnschr. **58**:1130, 1921.

21. Wimmer, A.: Pseudosklerose ohne Leberleiden, Zentralbl. f. d. ges. Neurol. u. Psychiat. **27**:370, 1922.

22. Jess, A.: Hornhautverkupferung in Form des Fleischerschen Pigmentringes der Pseudosklerose, Klin. Monatsbl. f. Augenh. **69**:218, 1922.

23. Gunther, M.: Beitrag zur Kenntnis der extra-pyramidalen Bewegungsstörungen in Gefolge körperlicher Erkrankungen, Arch. f. Psychiat. **72**:89, 1925.

24. Metzger: Fleischerscher Hornhautring bei hepatolentikulärer Degeneration, Klin. Monatsbl. f. Augenh. **69**:838, 1922.

25. Pillat, A.: Changes of the Eyeground in Wilson's Disease, Am. J. Ophth. **16**:1, 1933.

patient with gray-white spots in the retina. The retinal vessels were in front of these spots. They concluded that these were areas of retinal degeneration. Internal and external ophthalmoplegias have been noted in other cases. Chasanow [26] reported a case of associated atrophy of the optic nerve.

### SEXUAL CHARACTERISTICS

An important finding in my cases was marked hypogonadism, which has not been discussed much in the literature. In my cases the defect of the sexual organs was striking. It was demonstrated either by delayed onset of menstruation, amenorrhea or scanty menstruation, by underdeveloped genitalia or by sterility. How the sex organs are implicated in this disease is not clear. It is fortunate that the patients do not have much tendency to reproduce. None of my patients had any children.

R. W. menstruated only once, at the age of 16; at the time of writing she is 24. Her sister, D. W., menstruated once, at 15, and died at 16. Another sister, B. R., now aged 22, menstruated three times, at 16, 18 and 20. She married and lived with her husband three years, but she never became pregnant. Y. W., the twin sister of B. R., now also 22, began menstruating at 16. Her periods have recurred one to three times a year.

C. S. is a patient from another family. He is 16 and has markedly underdeveloped genitalia. In looking through the records at Montefiore Hospital I reviewed the case of R. S., a woman who died at 26. She began to menstruate at 16 and had periods two to three times a year.

### MENTALITY

The mentality of all the patients studied by me was below normal. Five of them were apparently of average mentality in their childhood and progressed in school. After about the age of 15, when the nervous symptoms developed, their mentality deteriorated gradually to a level corresponding to the age of 8 or 10 years. The sixth patient had never been bright and had made no progress in school. At the age of 16 he has the mental level of a child of 8 years.

The mental deterioration is explained by the study of the brain at autopsy. Degeneration of the brain is extensive and involves much more than the lenticular nucleus.

### HEREDITY

While isolated cases have been reported, most of the patients come from family groups. Consanguinity is an important factor in the inheritance. In each of the three families I observed the parents were first

26. Chasanow, M.: Ein Beitrag zur Klinik der Pseudosklerose, Ztschr. f. d. ges. Neurol. u. Psychiat. **116**:171, 1928.

cousins. In one family 3 sisters were affected, including twins. In another family a set of twin sisters was affected. In the third family there was only 1 patient. Many authors have emphasized a similar background in their cases. The gene of this disease is apparently inherited as a recessive characteristic.

### THEORIES OF ORIGIN

The patients are born without obvious abnormality and seem normal for the first decade or two of their lives. Though the basic defect depends on an inherited factor, it first manifests itself at about the age of 10 years, with the onset of hepatitis. This delayed appearance of a hereditary disorder is seen in other diseases, such as Leber's hereditary atrophy of the optic nerve, juvenile macular degeneration and retinitis pigmentosa. Wilson [1] expressed the opinion that lenticular degeneration is due to a toxin and is an acquired disease. Barnes and Hurst [27] postulated a toxin in the alimentary tract that gives rise to successive attacks of interstitial hepatitis. They stated that the cerebral abnormalities develop later and are a result of the hepatitis. Lhermitte and Muncie [28] reported 1 case in which they observed absence of hydrochloric acid in the fasting stomach and insignificant amounts after administration of histamine. They also reported a case in which hypoacidity was present. They suggested that the hypoacidity let down a barrier to the invasion of the gastrointestinal tract. I checked the gastric content in 3 cases and found normal quantities of hydrochloric acid. Brower [29] suggested that the syndrome may be due to a metabolic disturbance of the liposes. Various suggestions have been made regarding hereditary abiotrophy. Actually, physicians' knowledge of the cause of this disease is rather deficient, aside from some of the hereditary factors.

### PROGNOSIS AND TREATMENT

The disease is invariably fatal. The literature shows no report of recovery. So little is known of the disease that it is not surprising that no treatment has been found. In several of the cases observed at Montefiore Hospital extensive vitamin therapy was tried. The whole vitamin B complex, including vitamins $B_1$, and $B_6$, vitamin E and nicotinic acid, was given, without avail.

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27. Barnes, S., and Hurst, E. W.: Hepato-Lenticular Degeneration, Brain **48**:279, 1925; A Further Note on Hepato-Lenticular Degeneration, ibid. **49**:36, 1926; Hepato-Lenticular Degeneration: A Final Note, ibid. **52**:1, 1929.

28. Lhermitte, J., and Muncie, W. S.: Hepatolenticular Degeneration: A Report of Three Unusual Cases, Arch. Neurol. & Psychiat. **23**:750 (April) 1930.

29. Brower, B.: The Spleen, the Liver, the Brain, Proc. Roy. Soc. Med. **29**: 579, 1936.

## REPORT OF CASES

CASE 1.—C. S., a white boy aged 16, was born in the United States. He was of Russian Jewish extraction. His parents were first cousins.

He appeared normal at birth. His development was retarded. He began to speak at the age of 3 years. He started school at 6 years and stayed in the first grade three years, after which he was placed in the ungraded class. At the age of 16 he could write his name and address and a few simple words. He had chicken-pox and pertussis at 3 and measles at 6 years of age.

At the age of 8 years he had a "swollen belly" and swollen ankles. He was taken to Gouverneur Hospital, where ½ gallon (2 liters) of yellow fluid was removed from his abdomen on two occasions. He was not jaundiced, but he was pale. After three months at the hospital he went to a convalescent home for six months.

At the age of 12 he had a rash which lasted six weeks.

His family history was entirely irrelevant except for the consanguinity of his parents.

At the age of 15 he complained of generalized weakness and showed involuntary movements of his limbs with peculiar motions of his hands. There was generalized rigidity, with jerky movements which he had difficulty in controlling. His speech became impaired so that it was no longer clear.

*Physical Examination.*—The patient was 5 feet 4 inches (162.5 cm.) tall and weighed 75 pounds (34 Kg.).

He looked younger than his 16 years and appeared dull. His speech was difficult to understand. He assumed peculiar rigid postures, with occasional slow, awkward movements of his limbs. There were occasional sucking movements of his lips and a fine tremor of his outstretched hand.

Eyes: There were frequent spasmodic twitches of the lids. The eyeballs often rolled around in an irregular course, with jerky nystagmoid movements. A light was followed, but only for short periods. The extraocular muscles had a normal range of motion and balance. In the extreme positions a coarse nystagmus developed.

Each cornea had a typical Kayser-Fleischer ring 1.5 mm. broad. By reflected light or in diffuse illumination it appeared dark green-brown. Examination with the slit lamp showed that the ring was entirely on the posterior face of the cornea and was composed of two dark zones separated by a lighter ring. Under the slit lamp the pigment had a brighter (golden brown) appearance. The inner border of the ring was composed of many irregular dots of pigment. Farther toward the center of the cornea the posterior face had a delicate bluish tint for several millimeters, fading into clear cornea in the center. The rings were symmetric in appearance and position in the two eyes. The anterior chamber was clear; the iris was normal. The pupillary reactions were active and normal.

There was a delicate blue opacity on the anterior surface of each lens which resembled the typical Purtscher cataract. The opacity was in the pupillary zone and was roughly circular, with a diameter of 4 mm. The edges fuzzed out. Examination with the slit lamp showed delicate blue pigmentation in an extremely thin layer on the anterior surface of the lens. The opacity had the thickness of the corneal endothelium. The surface of the opacity was mottled.

The opacities were similar and quite symmetric in the two eyes. The remainder of the lens was transparent. The vitreous was clear. The fundi showed no abnormality. The disks were of good color. The blood vessels were normal.

There was no abnormal pigmentation. The vision in each eye was 20/30. The fields were normal for white and for colored test objects.

*Other Data.*—The patient had a high-arched palate. His ears and nose were normal. Examination of the heart and lungs disclosed no abnormality.

Examination of the abdomen showed mild distention. The edge of the liver was not palpable; the edge of the spleen was just felt. About the genitalia the pubic hair was sparse. The penis and the testicles were small for the patient's age.

The extremities were normal. The reflexes were normal, and there were no abnormal ones except a suggestive Babinski sign.

A roentgenogram of the skull showed no abnormality of the bony vault or of the sella turcica. Spinal and cisternal puncture showed normal pressure, a normal chemical picture and normal reactions.

Studies of the blood showed a normal chemical composition and a negative Wasserman reaction. The blood cell count was within normal limits. Urinalysis revealed no abnormality. The bilirubin content of the blood was 0.3 mg. per hundred cubic centimeters.

The mental age of the patient according to the Stanford-Binet test was 8 years and 4 months.

Electroencephalographic examination by Dr. Brill and Dr. Seidman showed an absence of normal alpha activity and the presence of continuous slow activity in all leads. This was interpreted as indicative of severe diffuse disturbance of cortical function.

Examination of the parents, a brother and five sisters revealed no abnormality. Examination of the relatives with the slit lamp failed to reveal any Kayser-Fleischer ring.

CASE 2.—R. W., a white woman aged 24, was of Russian Jewish extraction.

*Family History.*—The parents were first cousins. The patient's father died of pemphigus at the age of 36. Her mother was living and well.

Her sister, Ray W., who died at 16, was a patient at Montefiore Hospital with all the characteristic signs of hepatolenticular degeneration, including bilateral Kayser-Fleischer rings. She menstruated once, at the age of 15.

H. W., a brother, died in 1930, at the age of 19. He had a history of injury to the skull at 8. Two years later he had slow involuntary movements of the limbs, a shuffling gait, disturbances of speech and changes in facial expression. His mentality was rated at the 11 year level when he was 19. In addition, he had partially descended testicles. He was admitted to another hospital, where a diagnosis was made of chronic encephalitis with behavior disturbances, a dystonic syndrome and acrocyanosis. No record was found of an examination of his eyes for the Kayser-Fleischer ring. In view of the subsequent history of his family, it seems rather likely that he had hepatolenticular degeneration.

Two of the patient's sisters were identical twins. B. R. was the patient in case 3, and Y. W. was the patient in case 4. Both had hepatolenticular degeneration and a Kayser-Fleischer ring in each eye.

F. W., a sister aged 19, had been examined once, three years previously, at Montefiore Hospital. At that time it was noted that there were a Kayser-Fleischer ring in the left cornea and a suggestive ring in the right cornea, and she appeared bright. Though several attempts were made to examine her again, she proved elusive and has not been examined since. She probably has hepatolenticular degeneration.

*Past History.*—D. W., at the age of 7 years was in bed for a year with a swollen liver and was jaundiced for a few days. At the age of 12 she was at Gouverneur Hospital for five months with rheumatic polyarthritis. At the age of 14 she was hospitalized for three months for headaches and drowsiness.

When she was 15 she began to show the nervous symptoms typical of hepatolenticular degeneration. Her speech and swallowing became impaired. Tremors developed, and she had difficulty in holding objects. At the age of 16 she menstruated once for two days. She did not menstruate again.

*Physical Examination.*—The patient was able to get about. Her speech was thick and often unintelligible. She walked with a wide base and with jerky, irregular movements of her arms, which swung about uselessly. There was a slow tremor of both upper extremities.

Eyes: The eyes had jerky nystagmoid movements. There was a Kayser-Fleischer ring in each eye, about 2 mm. wide, starting sharply at the limbus and merging with a blue zone which extended 2 mm. in and then faded into the clear cornea in the center. The lenses were clear and the fundi normal. The vision of the right eye was 20/30 and that of the left eye 20/50 with correction. The fields of vision were normal. The color perception was good.

*Other Data.*—The heart and lungs were normal. Abdominal examination revealed no abnormality. Laboratory studies of the blood, spinal fluid and urine indicated normal conditions.

During her stay in the hospital she had an acute infection of the ear, and an operation on the mastoid was required. There were periods of fever for which no local cause could be found.

Case 3.—B. R., a woman aged 22, was the sister of the patient in case 2 and the twin sister of the patient in case 4.

She was married at 17 and lived with her husband for three years. She never became pregnant. She had menstruated only three times in her life, at the ages of 16, 18 and 20. According to her mother, she had been well and bright till the age of 16.

She had bilateral Kayser-Fleischer rings similar to those of her sister (case 2), with clear lenses. Her speech was thick, almost inarticulate. Her hands had a coarse tremor and frequent spasmodic, involuntary movements. Her mentality was far below the normal, no higher than that of a moron.

Case 4.—Y. W., a woman aged 22, single, was a sister of the patient in case 2 and the identical twin of the patient in case 3. Her defects were similar to those of her twin. She began to menstruate at 16. Since then menstruation had occurred one to three times a year. According to her mother she was normal till the age of 16.

There were bilateral Kayser-Fleischer rings and clear lenses. The speech was impaired. There were tremors and spasmodic movements of the limbs. Her mentality, like that of her twin sister, was far below normal.

The patients in cases 5 and 6 were identical twins, the daughters of first cousins. These have been previously reported on by Goodhart and Balser,[6] who particularly studied the localization of the wing-beating movements of their limbs.

Case 5.—E. H., a white woman aged 22, was of Austrian Jewish extraction. She complained of frequent headaches in the evening from the ages of 6 to 13 years.

At 15 she began to have tremors of the extremities and gradually showed symptoms of hepatolenticular degeneration. Menstruation began at the age of 13 and was normal.

The motions of her eyes were somewhat jerky. Convergence was very defective, almost absent. Kayser-Fleischer rings were present in both eyes, about 2 mm. wide. The lenses were clear and the fundi normal. The vision of each eye was 15/30, and the fields of vision were normal.

Her intelligence was fair, but her speech was considerably impaired, so that at times she was difficult to understand. There were tremors of the extremities and involuntary movements of the limbs. All the usual laboratory tests gave negative results. An encephalogram showed diffuse cortical atrophy.

CASE 6.—B. H., a white woman, was the twin sister of the patient in case 5. At the age of 10 she had an attack of enlargement of the abdomen with vomiting. Abdominal exploration showed atrophic cirrhosis of the liver. After repeated paracentesis she apparently recovered. At the age of 13 her speech became impaired; there developed jerky movements and tremors characteristic of hepatolenticular degeneration. Kayser-Fleischer rings were first noted at the age of 16. Menstruation began at 13 and recurred regularly.

*Physical Examination.*—There were occasional nystagmoid jerks of the eyes. There were bilateral Kayser-Fleischer rings. The lenses were clear and the fundi normal.

The speech was defective and the mentality slightly subnormal. The edges of the liver and spleen were palpable. There were tremors of the extremities, involuntary movements of the limbs and ataxia. Laboratory study revealed no abnormality. The encephalogram showed generalized cortical atrophy.

The patient died at the age of 21. Autopsy, performed at Montefiore Hospital, confirmed the diagnosis of hepatolenticular degeneration.

## SUMMARY

Six cases of hepatolenticular degeneration are reported. In all, the Kayser-Fleischer ring was present bilaterally. In 1 case there were bilateral bluish opacities on the anterior capsules of the lenses.

The chemical nature of the pigment of the Kayser-Fleischer ring has not been defined. The preponderance of the evidence points to urobilin as its probable basis.

Most of the patients described here had an attack of acute hepatitis before the age of 10, and atrophic cirrhosis of the liver developed later.

Mental deterioration was marked in all cases. In addition to lenticular degeneration, there was extensive degeneration of the brain.

Hypogonadism was present in 4 of these cases.

The 6 patients came from three families. The parents in each were first cousins. Among the persons affected were two sets of identical twins.

The disease is invariably fatal, usually within seven years, for no therapy has been of any avail. All the vitamins have been tried, without effect.

# BIOCHEMISTRY OF THE LENS

## XIV. PATHOGENESIS OF ELECTRIC CATARACT

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That lenticular opacities may result from severe electric shocks has been known for over two centuries. In 1722 de St. Yves [1] described the onset of cataract in a patient who had been struck by lightning. After the advent of controlled electric power, Desbrières and Bargy [2] reported similar lenticular changes after an electric shock. Although this type of cataract is by no means common, Robinson [3] in 1910 had already reviewed about 40 cases reported in the literature. Since then clinical reports have accumulated until this figure has been almost doubled. Lightning cataract and electric cataract show similar pathologic processes and may be considered as identical phenomena. No mention of ocular changes was made by Priestley,[4] who in 1776 studied the effects of electric discharge on the animal. Somewhat later Marat,[5] in similar experiments, reported an opacity of the cornea after shocking the head of a dog but mentioned no lenticular alteration. Hess [6] in 1888 was the first to investigate cataract resulting from experimental electric shock. He described in some detail the histologic changes resulting from the shock and showed microscopic changes to begin in the capsular epithelium within fifteen to thirty minutes after the animal is shocked. Areas of dead epithelium and detritus were found in the capsular epithelium, separated from dead fibers by fluid in which the more resistant nuclei could be seen bunched together. Posteriorly, a homogeneous fluid

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1. de St. Yves, C.: Les causes accidentelles, qui peuvent blesser la vue, in Nouveau traite des maladies des yeux, Paris, P. A. Le Mercier, 1722, p. 368; cited by von Szily,[22b] p. 261.

2. Desbrières and Bargy: Un cas de cataracte due à une décharge électrique industrielle, Ann. d'ocul. **133**:118, 1905.

3. Robinson, J. M.: Cataract Resulting from Electric Shock, Being a Brief Review of the Literature with a Report of Three Cases, Ophth. Rec. **20**:165, 1910.

4. Priestley, cited by Gabriélidès.[13]

5. Marat, cited by Gabriélidès.[13]

6. Hess, C., in Graefe, A., and Saemisch, E. T.: Handbuch der gesamten Augenheilkunde, ed. 3, Leipzig, Wilhelm Engelmann, 1911, pt. 2, chap. 9, p. 237.

had collected between the fibers and the capsule. The degenerative processes occurred more rapidly in some animals than in others, e. g. in the cat more rapidly than in the rabbit. It is generally agreed that the subcapsular position of the opacity is characteristic of lightning and electric cataract. Nevertheless, the form and site may show considerable variations, as is evident from the descriptions of the slit lamp findings of Koeppe,[7] Gjessing,[8] Frese,[9] Spir[10] and Bunge.[11]

Igersheimer[12] and Gabriélidès[13] called attention to the striking similarity of the lenticular changes in electric cataract to the changes shown by Vogt[14] to occur in cataracts experimentally produced by infra-red radiation. In vitro studies were first carried out by Kuwabara,[15] in 1909. He studied the effect of electric shocks produced by the Leyden jar on isolated calves' lenses immersed in saline solution. The loss of protein from the lens was taken as a measure of its injury.

In an attempt to gain further information on the fundamental nature of electric cataract, we investigated the alterations in the swelling propensities of the lens after exposure to high voltage current.

## EXPERIMENTS

Eyes from freshly killed cattle were cleaned of extraneous tissue and exposed to a high voltage (15 to 20 kilovolts), low frequency (60 cycle) current for short periods. The cornea was sparked for one, three or five seconds and the sclera for one, three, five or ten seconds. The exposed tissue was burned and coagulated. The tension of the eyeball increased during the sparking, the eye becoming much firmer. Sparkings of longer duration than those mentioned caused a perforation of the eyeball, the sclera being more resistant than the cornea. The rise in temperature of the fluids of the eye was negligible.

After this treatment the lenses were removed from the eyes and placed in freshly filtered pooled samples of vitreous humor for one hour. This was done to

7. Koeppe, L.: Ueber Spaltlampenbeobachtungen bei der Cataracta electrica, Klin. Monatsbl. f. Augenh. **66**:387, 1921.

8. Gjessing, H. G. A.: A Case of Cataracta Electrica Examined with Gullstrand's Slitlamp, Brit. J. Ophth. **6**:447, 1925.

9. Frese, H.: Ueber das Spaltlampenbild der Cataracta electrica mit experimentellen Untersuchungen an Kaninchen, Arch. f. Augenh. **91**:278, 1922.

10. Spir, E.: Ueber einen Fall von Starkstrom-Verletzung des Auges, Arch. f. Augenh. **90**:127, 1922.

11. Bunge, E.: Klinische Beiträge zur Pathologie der Linse: III. Eine Cataracta electrica, Ztschr. f. Augenh. **79**:5, 1932.

12. Igersheimer, J.: Starkstromkatarakt im Spaltlampenbild, Klin. Monatsbl. f. Augenh. **74**:518, 1925.

13. Gabriélidès, A.: Contribution a l'étude des cataractes électriques, Arch. d'opht. **52**:394, 1935.

14. Vogt, A.: Lehrbuch und Atlas der Spaltlampenmikroskopie des lebenden Auges, ed. 2, Berlin, Julius Springer, 1930, vol. 1.

15. Kuwabara, T.: Zur Pathogenese des Blitzstares, Arch. f. Augenh. **63**:1, 1909.

equalize slight changes in temperature and osmotic pressure of the individual lenses. At the end of this period, the lenses were removed from the vitreous, dried by rolling gently on filter paper, weighed and placed in distilled water for two hours. Then they were again dried and weighed, and the percentage of swelling was determined. This was compared with the swelling of control lenses of the same batch of eyes, which had undergone similar treatment except for the original sparking. As indicated in the accompanying table, a marked decrease in swelling was effected even after exposures as short as one second. Sparking the cornea and sparking the sclera proved of approximately equal effectiveness.

During dissection of the eyeball, it was noted that the zonular attachment of the ciliary body to the lens was fragile, so that the lens could be removed more

*Effect of Various Currents on Swelling of the Lens*

| Current | Voltage | Frequency, Cycles | Duration of Treatment, Seconds | % Swelling After Current / % Swelling of Control Lens | Comment |
|---|---|---|---|---|---|
| Alternating..... | 110 | 60 | 45 | 0.94 | |
| | | | 60 | 0.99 | |
| | | | 120 | 0.79 | |
| | | | 300 | 0.73 | |
| Direct..... | 110 | .. | 30 | 0.80 | |
| | | | 60 | 0.73 | |
| | | | 120 | 0.50 | |
| | | | 300 | 0.63 | |
| Alternating..... | 15,000-20,000 | 60 | 1 | 0.54 | Corneal exposure |
| | | | 3 | 0.43 | Corneal exposure |
| | | | 5 | 0.46 | Corneal exposure |
| | | | 1 | 0.57 | Scleral exposure |
| | | | 3 | 0.41 | Scleral exposure |
| | | | 5 | 0.45 | Scleral exposure |
| | | | 10 | 0.41 | Scleral exposure |
| Alternating..... | 10,000-15,000 | 750,000 | 5 | 1.11 | Corneal exposure |
| | | | 10 | 1.07 | Corneal exposure |
| | | | 20 | 0.96 | Corneal exposure |
| | | | 10 | 0.87 | Scleral exposure |

easily than is normal. This confirms Hess's [6] observation that the zonule is loosened, so that the lens separates readily from the ciliary body. A typical Vossius ring was deposited on the lens. The capsule was fragile and tore readily during removal of the lens.

Histologic examination revealed iris pigment deposited on the anterior surface of the lens. The capsule was detached, leaving patches of epithelial tissue on the cortex. Vacuoles were seen occasionally. Under the posterior pole a homogeneous-staining area (liquefied cortex) could be seen.

In another group of lenses, after sparking of the eyeball the capsules were removed and their permeability tested by Friedenwald's [16] technic as modified

16. Friedenwald, J. S.: Permeability of the Lens Capsule with Special Reference to the Etiology of Senile Cataract, Arch. Ophth. **3**:182 (Feb.) 1930; The Permeability of the Lens Capsule to Water, Dextrose and Other Sugars, ibid. **4**:350 (Sept.) 1930.

by Bellows and Rosner.[17] The passage of glutathione through the membrane was determined and compared with its passage through control capsules. No alteration could be detected. Nor was there any apparent difference between the glutathione and ascorbic acid content of normal lenses and that of lenses from eyes exposed to the high voltage current.

When a high voltage was produced together with a high frequency the marked changes described were not seen. A voltage of approximately the same magnitude (10 to 15 kilovolts) was developed with a Victor variofrequency diathermy apparatus having a frequency of 750 kilocycles. After the sclera was sparked for ten seconds the lens showed a slight diminution in its swelling. This was far less than was obtained with the low frequency current. Sparking the cornea resulted in little change of the lens.

Lenses were also exposed to the effect of low voltage direct and alternating current. Fresh lenses were immersed in Ringer's solution and subjected to a 110 volt, 60 cycle current passing through the solution for forty-five to three hundred seconds. Because of its heating effect, the current was maintained for fifteen second intervals until the desired total had been attained. The temperature at all times was maintained below 40 C. For the longer periods there was decreased swelling with the alternating current, but in no instance was this diminution as marked as that obtained when 110 volt direct current was passed through the solution for the same length of time.

## COMMENT

The marked decrease in the water uptake of the lens following an exposure to high voltage current as short as one second seems significant in the evolution of electric cataract. The greater effect of current of low frequency over that of high frequency is probably explained by the Tesla, or cutaneous, effects produced by the latter current. In this phenomenon, a high frequency current tends to distribute itself on the surface of a body rather than to penetrate it. The higher the frequency, the wider the surface distribution and the less current passing through the body. The diminished effect on the lens of high frequency currents was thus probably due to a shunting of much of the current around the eyeball. Slight decreases of swelling were observed in the lenses, indicating some effect.

The theories explaining the pathogenesis of electric cataract are numerous and varied. Some workers [17a] have maintained that the lens fibers themselves are injured by the current, the injury resulting eventually in the death of the lens. It was found that isolated lenses exposed directly to the spark from several Leyden jars showed a higher water uptake than control lenses when immersed in 0.9 per cent solution of sodium chloride. On the intact eye, this effect was negligible. In

17. Bellows, J., and Rosner, L.: Biochemistry of the Lens: XI. Effect of Galactose on Permeability of the Capsule of the Lens, Arch. Ophth. **20**:80 (July) 1938.

17a. Croci, L.: Cataratta elettrica sperimentale, Cong. Soc. oftal. ital., 1932; cited by von Szily.[22b]

both instances there was a slight increase of protein leakage through the capsule. Because of the unique nutrition and poor regenerative power, the lens could not recover from the injury, and permanent opacity followed. Leber [18] expressed the belief that an actual coagulation of the protein resulted from a "catalytic" action of the electricity. As Robinson [3] has pointed out, such a direct coagulation effect would be most marked at the time of shock and opacities would appear immediately rather than several months later. There is no anatomic confirmation to Yvert's [19] belief that tears in the lens capsule are the primary change. Strong objections [6] exist to Knies's [20] hypothesis that a powerful contraction of the ciliary muscle following shock produces a displacement of lens elements. Silex [21] stated that the symmetric appearance of the cataracts indicates a diseased condition of the nerve fibers. No support of this position has appeared. The iridocyclitis associated with the cataractous condition has been emphasized as an important factor in the cause of the opacity.[22] The findings of Kiribuchi,[23] Hess [6] and Frese [9] support such a relation. Comberg,[24] on the other hand, expressed the belief that the changes result directly from the action of the current. He reported that lenticular changes occurred no more rapidly when there was associated severe uveitis than when there was a minimum of irritation. Widmark [25] and later Silfvast [26] attributed the cataract to the action of ultraviolet rays produced during the shock on the lens, a view essentially that of Licskó,[27] who assumed the damage to arise from the

18. Leber, T.: Ueber Katarakt und sonstige Augenaffektionen durch Blitzschlag, Arch. f. Ophth. **28**:255, 1882.

19. Yvert, L. A.: Traité pratique et clinique des blessures du globe de l'oeil, Paris, Germer-Baillière & Cie, 1880, p. 20; cited by von Szily.[22b]

20. Knies, M.: Ein Fall von Augenaffektion durch Blitzschlag, Arch. f. Ophth. **32**:236, 1886.

21. Silex, P.: Beitrag zur Kasuistik der Affektionen infolge von Blitzschlag, Arch. f. Augenh. **18**:65, 1887.

22. (*a*) Vossius, A.: Ein Fall von Blitzaffektion der Augen, Beitr. z. Augenh., 1892, no. 4, pt. 1; cited by von Szily. (*b*) von Szily, A.: Der Blitzstar und der Star durch electrischen Strom, in Henke, F., and Lubarsch, O.: Handbuch der speziellen pathologischen Anatomie und Histologie, Berlin, Julius Springer, 1937, vol. 11, pt. 3.

23. Kiribuchi, K.: Experimentelle Untersuchungen über Katarakt und sonstige Augenaffektionen durch Blitzschlag, Arch. f. Ophth. **50**:1, 1900.

24. Comberg, W.: Problem of Electric Cataract, Arch. Ophth. **18**:678 (Oct.) 1937.

25. Widmark, J.: The Effect of Strong Light on the Crystalline Lens, Hygiea **63**:641, 1901; abstracted, Ztschr. f. Augenh. **7**:173, 1902.

26. Silfvast, J.: A Case of Ocular Lesions Due to Lightning, Finska läk.-sällsk. handl. **44**:273, 1902; abstracted, Ztschr. f. Augenh. **9**:320, 1903.

27. Licskó, A.: Three Cases of Electric Cataract, Szemészet **56**:17, 1922; abstracted, Zentralbl. f. d. ges. Ophth. **9**:235, 1923; cited by von Szily.[22b]

radiant energy of the ultraviolet and infra-red rays thus developed. Hess expressed the opinion that the extensive necrosis of the capsular epithelium initiates alterations of the lens, terminating in cataract. Terrien [28] supported this view to a limited extent. He concluded that the mechanical and electrolytic action of the current on the lens is responsible, and particularly its action on the subcapsular epithelium.

Much the same opinion has been expressed by Gabriélidès,[13] who extended the theory to include chemical changes in the aqueous humor produced by the current. He envisaged three factors capable of producing lenticular opacities following high voltage shock: (1) circulatory disorders of the anterior portion of the eye, (2) chemical alterations and (3) traumatic and destructive action of the current.

It is difficult to see how most of these theories could afford any explanation for our findings. If the absorption of water across the capsule is an active process depending on the integrity of the epithelial cells, then damage to these cells might easily decrease the absorption of water. However, it has never been demonstrated that water is absorbed through an active mechanism of this sort. The passage of water across the capsule is usually considered a purely physical process of diffusion and osmosis. Furthermore, injury to the corneal epithelium or endothelium results in an increased permeability. By analogy, injury to the lenticular epithelium should produce an increased water uptake. The possibility that the decreased absorption was due to chemical changes of the lens substance cannot be dismissed. However, we detected no decrease in the glutathione or ascorbic acid content of the lens, and diminished values for these compounds are usually among the earliest chemical changes apparent. Furthermore, if actual degenerative changes of the lens substance could occur in the time designated, these alterations would increase the internal osmotic pressure and the swelling tendency would be increased rather than decreased.

The explanation for the greater effect of direct current on the swelling of the lens is obscure. Possibly it lies in the capacitance effect of the lens in the alternating current circuit, which might result in a diminished flow of current. Another factor that might account partially for the difference would be the greater tendency with direct current for ions to penetrate and to leave the lens.

Our findings suggest, therefore, that other factors may be vitally concerned with the pathogenesis of electric cataract. The most obvious alteration would be a change of capsular permeability. Yet we were unable to detect any decrease in permeability of the isolated lenticular capsule. Whether the individual lens fibers showed permeability or

28. Terrien, F.: Paper read before the Société d'ophthalmologie de Paris, Nov. 3, 1908; abstracted, Arch. Ophth. **39**:403, 1910.

chemical changes could not be tested directly. Slight alterations of the individual fibers might be tremendously magnified when the additive effect on all the fibers is considered. Further experimental work is essential to elucidate the pathogenesis of electric cataract.

SUMMARY

A striking decrease in the swelling of lenses in distilled water was noted after exposure of beef eyes to high voltage current for one to ten seconds.

When eyes were shocked, the swelling effect on the lens was less marked with high voltage, high frequency current than with low frequency current of comparable voltage.

Passage of low voltage direct current through a solution containing a lens decreased the swelling tendency of that lens. If alternating current was passed through for equal periods, the swelling of the lens was below normal but not so low as with direct current.

The theories of electric cataract are discussed in the light of our findings.

# THIAMINE HYDROCHLORIDE IN THE TREATMENT OF TRYPARSAMIDE AMBLYOPIA

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AND
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The use of the various vitamins in the treatment of ocular and neurologic diseases has led in some instances to satisfactory results. Because of the value of thiamine (vitamin $B_1$) hydrochloride in the treatment of tobacco and alcohol amblyopia, as well as of certain forms of peripheral neuritis, it was reasonable to assume that this vitamin might have some effect on the process responsible for tryparsamide reactions. In 1939, Muncy [1] reported 50 cases in which "vitamin B" ($B_1$) and "B complex" were administered during the course of tryparsamide therapy, and from his study of these cases he gained the impression that yeast tablets are protective against tryparsamide amblyopia. He also reported the case of a patient in whom preexisting tryparsamide amblyopia was improved after administration of the yeast tablets.

To test this assumption further, we felt that it would be desirable to utilize thiamine hydrochloride in large intramuscular doses for those patients who showed changes in the visual fields after administration of the drug. The histories of 2 patients in whom ocular reactions were observed are recorded here. The first patient had a clinical pellagra prior to the administration of tryparsamide and had been given therapeutic oral doses of thiamine hydrochloride and nicotinic acid for eleven days before the first injection of tryparsamide. Vitamin therapy was continued in increased doses after the appearance of the toxic reaction to tryparsamide. For the second patient vitamin therapy was not utilized until definite evidence of peripheral contraction of the visual fields had occurred.

## REPORT OF CASES

CASE 1.—A white man 41 years of age was admitted to the neurologic service on Oct. 3, 1940 because of dizziness, pain in the legs and headaches. Physical examination revealed unequal pupils that were fixed to light and sluggish in

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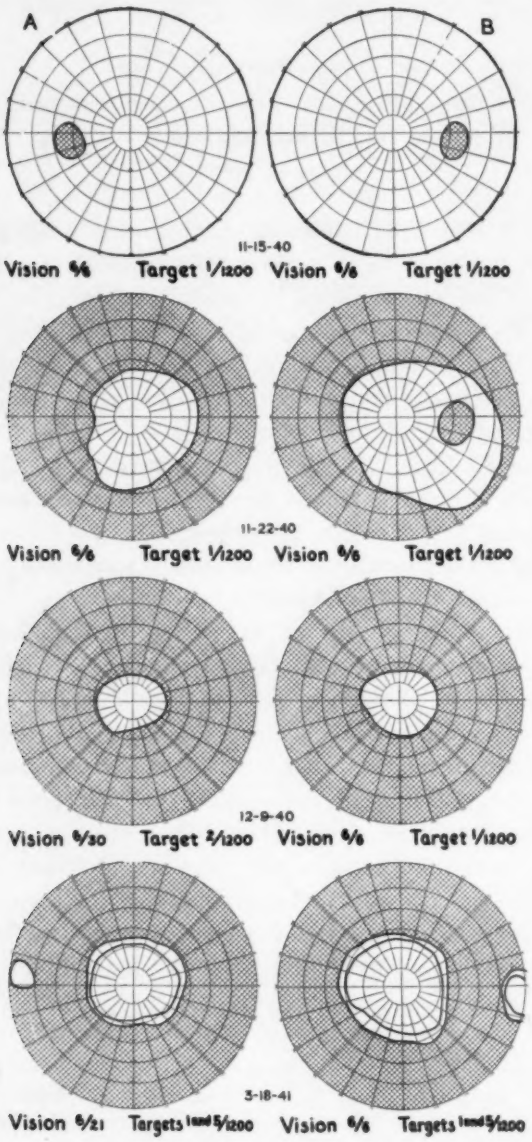
1. Muncy, W. M.: The Relationship of Tryparsamide Reaction to Vitamin Deficiency, Tr. Am. Acad. Ophth. **44**:134-150, 1939.

response to accommodation stimuli. There was slight ataxia; the deep reflexes were absent; the Romberg test gave a positive result, with falling; pain transmission was delayed, and there was a cord bladder. Except for slight secondary


A
B
11-15-40
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Vision 6/6 Target 1/1200 Vision 6/6 Target 1/1200
12-9-40
Vision 6/30 Target 2/1200 Vision 6/6 Target 1/1200
3-18-41
Vision 6/21 Targets 1 and 5/1200 Vision 6/6 Targets 1 and 5/1200

Chart 1.—Visual fields in case 1. *A*, left eye; *B*, right eye.

anemia the blood picture was normal. The Wassermann reactions of the blood and of the spinal fluid were positive. The vision was 6/6 in each eye, and the fundi and visual fields were normal.

On October 7 the patient was inoculated with malarial blood. After twelve chills, with an average temperature of 104 F., quinine sulfate in doses of 650 mg. three times a day was administered for seven days. Toward the end of the period of induced malaria the patient complained of weakness and poor appetite. His general appearance was not good, and there was some increase of his anemia. The tongue was smooth, shiny and fiery red, and the buccal angles were fissured. A diagnosis of vitamin deprivation of the pellagrous type was made, and the administration of thiamine hydrochloride (10 mg. three times a day) and nicotinic acid (75 mg. three times a day) by mouth was begun on October 26. With this regimen the patient's appetite and general condition improved rapidly. On November 6, after the administration of a total of 300 mg. of thiamine hydrochloride and 2,250 mg. of nicotinic acid in eleven days, tryparsamide therapy was begun with an intravenous injection of 1.0 Gm.. The vitamin therapy was reduced to daily oral administrations of 10 mg. of thiamine chloride and 25 mg. of nicotinic acid. Tryparsamide in doses of 2 Gm. on November 9 and 3 Gm. on November 13, 16 and 20 was given. The vision remained 6/6 in each eye, and the visual fields and fundi were normal.

On November 21 the patient complained of blurred vision. The fundi were normal, and on November 22, although there was concentric contraction of the fields, the vision remained normal. The daily dose of thiamine hydrochloride was increased to 30 mg. given orally and from 30 to 80 mg. given intramuscularly, and nicotinic acid was given in divided oral doses of 300 to 375 mg. per day. The patient also received orally 50 mg. of ascorbic acid each day. Further contraction of the visual fields was noted on November 27 and 30, and, although the patient still complained of blurring, the vision and the fundi were normal. Vitamin therapy was continued as described, but further constriction of the visual fields ensued until December 9. At the time of the patient's discharge, on December 15, no additional contraction was disclosed. No changes occurred in the fundi, but on December 4 there was acute loss of vision (to 6/15) in the left eye; this was attributed to acute iridocyclitis with secondary glaucoma. The increased tension responded to the use of scopolamine hydrobromide drops (0.2 per cent), and the iridocyclitis gradually improved. On discharge, although vision in the right eye was 6/6, vision in the left eye was reduced to 6/60 because of clouding of the cornea. A slight circumcorneal flush and a moderate number of floaters in the aqueous persisted. At the time of discharge this patient showed no improvement in the visual fields even though he received a total dose of 2,190 mg. of thiamine hydrochloride, 11,775 mg. of nicotinic acid and 1,125 mg. of ascorbic acid. When the patient returned, on March 31, 1941, the vision in the right eye was 6/6, while that in the left had improved to 6/21. Although both visual fields showed some improvement, a marked concentric contraction was present, and both optic nerve heads showed evidence of atrophy.

CASE 2.—A 39 year old white woman was admitted to the neurologic service on Oct. 3, 1940, because of generalized headaches and occasional blurring of vision in the left eye. In 1923 and 1933 she had received inadequate antisyphilitic therapy. No significant abnormalities were revealed by general examination. The vision was 6/6 in each eye. There were bilateral Argyll Robertson pupils, but the visual fields and the fundi were normal. The Wassermann reaction of the blood and that of the spinal fluid were positive. On October 7 the patient was inoculated with malarial blood and thereafter had eleven chills, with an average temperature of 105 F. The course was terminated with quinine sulfate according to the usual method, and no chills occurred after October 27. She had complained

of weakness and was restless and irritable during the course of the malaria, but in spite of this she was able to be up and about the ward. In the succeeding days she improved rapidly, and her condition was excellent on November 6, when

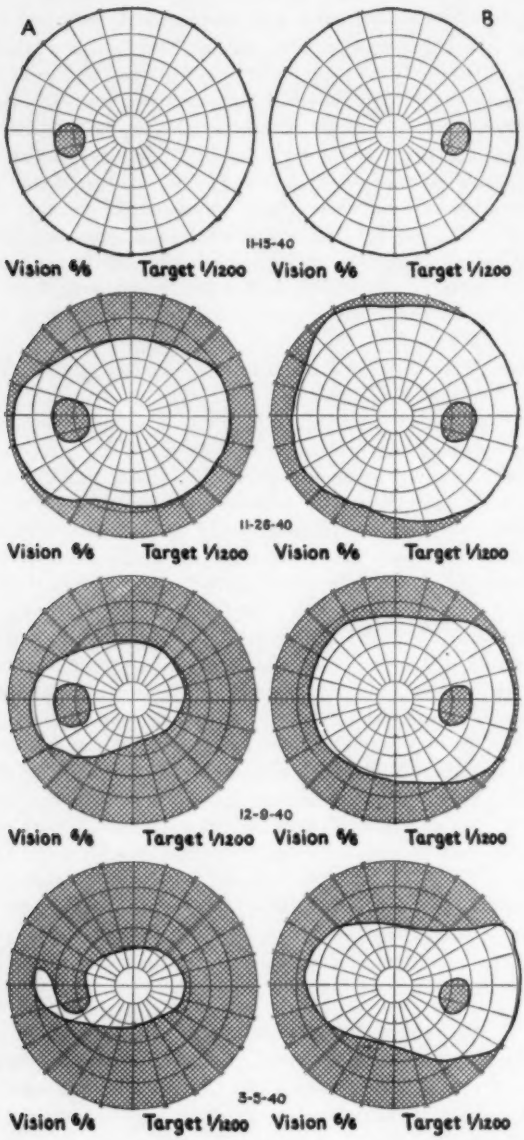


Chart 2.—Visual fields in case 2. *A*, left eye; *B*, right eye.

she received 1.0 Gm. of tryparsamide intravenously. This was followed by 2.0 Gm. on November 9 and 3.0 Gm. on November 13, 16 and 20. The visual fields were checked at weekly intervals, and they were normal until November 22,

when a slight peripheral contraction was observed; the vision and the fundi remained normal. Since it could not be determined that the changes in the visual fields were due to damage caused by tryparsamide, 3.0 Gm. of the arsenical was given on November 23. Although it was recognized that further contraction of the visual fields had occurred on November 26, a final dose of 3.0 Gm. of tryparsamide was administered on November 27.

Daily intramuscular injections of thiamine hydrochloride in 30 Gm. doses and nicotinic acid in oral doses up to 375 mg. were begun on November 26. The patient also received 50 mg. of ascorbic acid daily by mouth. The visual fields continued to show progressive concentric contraction until December 4, at which time only a slight increase in the contraction was noted in the left eye. On December 10 there was no further change in the visual fields; the fundi were normal, and, although the patient had complained of slight veiling of the vision during the previous week, the vision remained 6/6 in each eye. A total dose of 450 mg. of thiamine hydrochloride, 3,200 mg. of nicotinic acid and 625 mg. of ascorbic acid had been administered during the fifteen days following the onset of constriction of the visual fields. On March 5, 1941, the patient returned with vision of 6/6 in each eye. The visual fields showed further contraction, but ophthalmoscopic examination disclosed no pathologic change.

## COMMENT

In our 2 cases the use of thiamine hydrochloride was of no value in the treatment of changes in the visual fields occurring as a result of tryparsamide therapy. Although in both cases the patients received large doses of the vitamin, the visual fields continued to undergo progressive contraction. In these cases the dose was adequate for therapeutic purposes. The question of absorption does not arise, since the administration was by intramuscular injection.

The apparently satisfactory experience of Muncy in prophylaxis and therapy are not due, in our opinion, to any advantage of yeast over thiamine hydrochloride. His conclusions in a series of 50 cases are dependent on the fact that visual changes did not occur in his patients. This does not prove a direct relation between the vitamin B complex or thiamine and the tryparsamide reaction, since it is known that the occurrence of amblyopia is sporadic and that large series of cases may be observed without the development of ocular complications. Also, it is difficult to evaluate therapeutic results, since a certain degree of improvement occurs even in patients who do not receive treatment; in cases in which the involvement is mild complete spontaneous recovery may result. Therefore Muncy's single case of improvement following the administration of yeast tablets cannot be considered evidence of the therapeutic value of the vitamin B complex in cases of tryparsamide amblyopia.

In our cases nicotinic acid was used as a vasodilator and not for its specific vitamin effect. The dose was increased until flushing of the skin was obtained shortly after administration of the substance. Ascorbic acid was given in doses too small to have any therapeutic effect.

It should be noted that the patient in case 2 received one injection of tryparsamide after definite recognition of the constriction in the visual fields. This was given because it was hoped that the use of thiamine hydrochloride might prevent further changes in the fields and allow continuation of the treatment. However, when the fields showed further constriction, the administration of tryparsamide was discontinued.

That thiamine hydrochloride has no prophylactic effect is demonstrated by case 1. In this case, therapeutic doses of thiamine hydrochloride and nicotinic acid resulted in rapid improvement of the pellagra syndrome, but the occurrence of an ocular tryparsamide reaction was not prevented.

The end result in these cases was good in that visual acuity remained normal in one patient and would perhaps have been normal in the other if clouding of the cornea had not followed the iridocyclitis in the left eye. We do not feel that thiamine hydrochloride had any mitigating effect on the severity of the tryparsamide reactions, for if that were true it should have been demonstrated definitely by the visual fields. It cannot be concluded that thiamine hydrochloride or nicotinic acid has any significant effect on the occurrence or progress of changes in the visual fields following tryparsamide therapy.

# MONOCULAR MYASTHENIA GRAVIS

## PROSTIGMINE METHYLSULFATE AS A DIFFERENTIAL DIAGNOSTIC AGENT

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Ocular symptoms and signs are almost invariably present in a case of overt myasthenia gravis and frequently may be the first manifestations of the condition. No diagnostic difficulty arises if the history and physical examination reveal, in addition to ptosis, diplopia and opthalmoplegias of changing character, such symptoms as ready fatigability on slight exertion, weakness or paralysis of speech, chewing or swallowing, facial diplegia and easily exhausted tendon reflexes. A definite differential diagnosis may then be established by employing corroborative diagnostic criteria, such as the Jolly reaction,[1] the data from electromyographic and ergographic studies [2] and the response to prostigmine methylsulfate (dimethylcarbamic ester of hydroxyphenyltrimethylammonium methylsulfate). It is easy to make the diagnosis of myasthenia gravis when several characteristic symptoms are in evidence. However, when the presenting symptoms and signs consist merely of ptosis of one eyelid or ptosis of one lid and diplopia, the resemblance to other ophthalmologic or neurologic entities often obscures the correct diagnosis and may lead to erroneous diagnosis and treatment.

The following cases illustrate, first, myasthenia gravis with monocular symptoms simulating neurosyphilis or organic unilateral oculomotor palsy and, second, the use of prostigmine methylsulfate as a pharmacologic differential diagnostic agent.

### REPORT OF CASES

CASE 1.—J. W., a man aged 51, noticed drooping of the left upper eyelid in May 1939. At the same time he became aware of a difference in the size of the pupils. He was suffering from acute sinusitis at the onset of his ocular symptoms. After consulting several ophthalmologists, he was referred to me by his family

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Read before the Section on Ophthalmology of the Philadelphia County Medical Society, April 3, 1941.

1. Oppenheim, H.: Die myasthenische Paralyse, Berlin, S. Karger, 1901.

2. Lindsley, D. B.: Myographic and Electromyographic Studies of Myasthenia Gravis, Brain **58**:470-482, 1935.

physician to determine whether his ocular disturbance was due to neurosyphilis. The patient had been employed as a traveling salesman throughout his married life (thirty-two years). His wife had one living child (31 years old at the time of examination), two induced abortions and no spontaneous miscarriages. At the time of my first examination, in August 1939, the drooping of the left eyelid had become extremely annoying, and in the morning he found it necessary to resort to lifting it with his hand. The weakness lessened as the day wore on. He emphasized the fact that he had never noticed a difference in the size of his pupils until the weakness of the eyelid appeared. At no time had he noticed double vision.

Fig. 1 (case 1).—*A*, partial ptosis of the left upper lid associated with smallness and inequality of the pupils and absence of knee jerks (reenforcement not employed). *B*, patient ten minutes after the intramuscular injection of 2 cc. of a 1:2,000 solution of prostigmine methylsulfate and 1/150 grain (0.4 mg.) of atropine sulfate. Note the spontaneous elevation of the left upper lid, with formation of a normal palpebral fold.

Fig. 2.—Partial ptosis of the left upper lid, Argyll Robertson pupil and absence of patellar and achilles tendon jerks (case of meningovascular syphilis and tabes dorsalis). Compare with figure 1 *A*. This photograph was taken fifteen minutes after the intramuscular injection of 3 cc. of a 1:2,000 solution of prostigmine methylsulfate and 1/150 grain (0.4 mg.) of atropine sulfate. No difference could be noted in the appearance of the left eye before the injection and for several hours after the injection.

Neurologic examination disclosed ptosis of the left upper eyelid. The left lower lid was normally apposed to the orbit. The two eyes could be closed equally well, but he was unable to elevate the left upper lid. The pupils were small and unequal, and they responded to light and in accommodation. The extraocular movements were well performed in all directions. Both fundi were normal.

The remaining cranial nerves showed no abnormalities. The tendon reflexes in the upper extremities were present and equal. The knee jerks could not be obtained unless Jendrassik's reenforcement was utilized. The ankle jerks were present and equal. There were no disturbances as regards motor power, sensation, coordination or gait. The Wassermann reaction of the blood was negative.

The combination of ptosis of one eyelid, smallness and inequality of the pupils and absence of knee jerks probably led the referring physician to desire to eliminate neurosyphilis as the possible cause. The history of marked variation in the degree of ptosis from day to day and the difference as of the morning and the latter part of the day inclined me to consider the ptosis a myasthenic reaction. Moreover, the pupils, though unequal, responded to light stimulation; the knee jerks could be elicited by reenforcement; the optic disks were normal, and no disturbances of deep sensibility could be found, thus eliminating the diagnosis of meningovascular syphilis or tabes dorsalis. The ocular signs and symptoms presented by this patient resembled closely those seen in 2 patients suffering from myasthenia gravis who had been reported on by Winkelman and myself [3] in 1937 (cases 2 and 3). In order to determine whether the ptosis was a beginning manifestation or a partial form of myasthenia gravis, I injected 2 cc. of a 1:2,000 solution of prostigmine methylsulfate and 1/150 grain (0.4 mg.) of atropine sulfate intramuscularly. After five minutes a distinct elevation of the left eyelid was apparent; voluntary elevation could be partly effected. The ptosis was still less evident at the end of ten minutes, and after fifteen minutes it had completely disappeared. Voluntary elevation of the lid was easily carried out fifteen minutes after the injection of prostigmine. The patient was instructed to take one 15 mg. tablet of prostigmine bromide three times daily. This dose proved inadequate, and he then took two tablets of prostigmine bromide (30 mg.) three times daily. With this dose he obtained complete relief of symptoms and did not experience intestinal cramps.

Case 2.—L. N., a woman aged 53, one week before being referred to me consulted an ophthalmologist because of the abrupt closure of her right eye. Another complaint was double vision, which, however, had been present for three years. The double vision had also come on suddenly and had remained constant since its onset. This had been extremely annoying, and the complete drooping of the right upper eyelid, although it was disfiguring, dispelled the double vision. In the morning the right eye was partly open, but as the day advanced the upper lid drooped, so that by noon or early afternoon the eye was completely closed. The menopause had occurred at the age of 46. For the past five years she had been receiving an estrogenic substance to overcome the severe flushes and other vasomotor disturbances from which she suffered. She had had shooting pains in the legs and in both elbows for eight years. She had been married nineteen years and had one child, 17 years old. There had been no subsequent pregnancies.

There was complete ptosis of the right upper eyelid. The patient could open the eye partly only after severe effort and by resorting to an associated movement of the head. The lid could be maintained in the raised position for but a few seconds, after which it dropped completely. The fundi presented no gross changes.

3. Winkelman, N. W., and Moore, M. T.: Prostigmin in the Treatment of Myasthenia Gravis and Muscular Dystrophy, Arch. Neurol. & Psychiat. **37**:237-252 (Feb.) 1937.

The pupils were round, regular and equal and responded to light and in accommodation. The consensual light reflex was normal. There were a vertical muscle imbalance of 8 degrees and a moderate disassociation of lateral movement. The right eye could be moved laterally to fill the inner and outer canthi fully, as could the left eye. When the right eyelid was manually elevated, double vision immediately came on and made the patient dizzy. The two eyes could be closed with the same degree of intensity. No deviation from the normal was found in the remaining cranial nerves. Muscle power in all four limbs was normal and was equal on the two sides. The tendon reflexes in the upper limbs were diminished. The knee and ankle jerks were considerably diminished but were equal on the two

Fig. 3 (case 2).—*A*, complete ptosis of the right upper lid prior to injection of prostigmine methylsulfate. *B*, patient ten minutes after the intramuscular injection of 3 cc. of a 1:2,000 solution of prostigmine methylsulfate and 1/150 grain (0.4 mg.) of atropine sulfate. Note the spontaneous elevation of the right upper lid. There is still evidence of muscle imbalance, as shown by the squint.

Fig. 4.—Complete paralysis of the right oculomotor nerve produced by an interpeduncular lesion. Compare with figure 3 *A*. This photograph was taken fifteen minutes after the intramuscular injection of 3 cc. of a 1:2,000 solution of prostigmine methylsulfate and 1/150 grain (0.4 mg.) of atropine sulfate. There was no spontaneous or effort elevation of the right upper lid at any time after the use of the prostigmine salt.

sides. The remainder of the neurologic examination gave entirely negative results. The Wassermann reaction of the blood was negative.

At first glance, before detailed examination, the complete ptosis of the right upper eyelid associated with a normal left eye presented the appearance of a paralysis of the right oculomotor nerve. Examination of the extraocular movements and pupillary responses of the right eye indicated that a nuclear or extranuclear oculomotor paralysis did not exist. The remark made by the patient

regarding the changing nature of the ptosis induced me to regard the ptosis as a possible monocular myasthenic reaction. Three cubic centimeters of a 1:2,000 solution of prostigmine methylsulfate and 1/150 grain (0.4 mg.) of atropine sulfate was injected intramuscularly. Within two minutes the right eye was slightly open. After six minutes the right eye was three-quarters open, and at the expiration of fifteen minutes it was entirely open. As is shown in figure 3 *B*, there was a muscle imbalance, and she complained of double vision which made her slightly dizzy. She was instructed to take one tablet (15 mg.) of prostigmine bromide four times daily. The diplopia improved rapidly, and the ptosis diminished. After one week she took two tablets (30 mg.) of prostigmine bromide four times daily. This completely eliminated the diplopia and ptosis but she complained of intestinal cramps. Atropine sulfate (1/150 grain) taken with each dose of prostigmine bromide failed to prevent or check the cramps. A return to one tablet four times a day without atropine resulted in clearing up of the symptoms (figs. 3, 4 and 5).

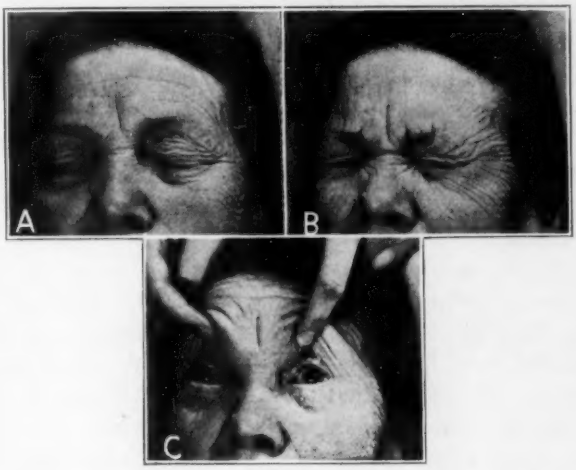


Fig. 5.—Polioencephalitis haemorrhagica superior of Wernicke. *A*, bilateral complete ptosis with no response to voluntary effort to open the eyes. *B*, response to voluntary closure of the lids (orbicularis oculi muscle intact). *C*, patient fifteen minutes after the injection of 0.0015 Gm. of prostigmine methylsulfate and 0.0006 Gm. of atropine sulfate. The patient showed no spontaneous or voluntary opening of the lids. Note the divergent squint when the lids are raised manually.

## COMMENT

The history and neurologic examination in the first case gave no supportive evidence of several of the characteristic signs of myasthenia gravis. The resemblance of the condition to an early form of tabes dorsalis was striking. In a similar case previously reported by Winkelman and me [3] a diagnosis of neurosyphilis and a post-traumatic state had been made, and antisyphilitic treatment and operative procedures had been carried out both in the United States and abroad before the correct diagnosis was made and corroborated by the use of prostigmine methylsulfate.

In case 2 the extreme ptosis with the accompanying diplopia and squint resembled, though not definitely, an organic paralysis of the oculomotor nerve.

In both cases, as is shown in the illustrations, the patients had as the presenting sign ptosis of one eyelid. The characteristic myasthenic facies was not present, nor were the bulbar symptoms of difficult chewing, swallowing and phonation; thus myasthenia gravis had not been suspected by previous examiners.

Oppenheim [4] credited Karplus with first calling attention to ptosis and/or diplopia as an isolated symptom of myasthenia gravis. A review of the numerous cases reported in the literature to date indicates that not only are ocular signs and symptoms almost constantly associated with myasthenia gravis, but frequently they are the earliest signs and as such often are not properly evaluated until a full-fledged picture of myasthenia gravis has developed.

The need for a diagnostic test in the early stages is evident, since it is obviously inadvisable to wait for the establishment of more than one characteristic symptom of myasthenia gravis before making the diagnosis. Ptosis is an objective symptom which lends itself well to measurement.

However, tests for myasthenia gravis, such as the Jolly test and electromyographic and ergographic studies, either are unsuitable for testing ptosis or require cumbersome laboratory apparatus. By the measurable response to prostigmine methylsulfate, as shown in the cases illustrated here, it is now possible definitely to label monosymptomatic ptosis or diplopia as due to myasthenia gravis and to differentiate it from ptosis or diplopia of organic origin. When ptosis is the outstanding sign, the effect produced by prostigmine methylsulfate can be observed directly or can be measured with calipers. Organic ptosis due to neurosyphilis (fig. 2), to an interpeduncular lesion (fig. 4) and to polioencephalitis haemorrhagica superior of Wernicke (fig. 5) showed no response to prostigmine methylsulfate, whereas ptosis due to myasthenia gravis (figs. 1 and 3) was measurably improved in case 1, and obviously improved in case 2, within a matter of minutes.

Schwab and Viets [5] have elaborated a differential diagnostic test based on the objective and subjective response to prostigmine methylsulfate, which is scored numerically. With a maximum score of 48, they consider a total value of less than 10 as indicating a negative result. They have found this to be so in 68 cases of diseases the signs

4. Oppenheim, H.: Textbook of Nervous Diseases, Edinburgh, Otto Schulze & Co., 1911, vol. 2, p. 1030.

5. Schwab, R. S., and Viets, H. R.: The Prostigmin Test in Myasthenia Gravis: Third Report, New England J. Med. **219**:226-228 (Aug. 18) 1938.

and symptoms of which resemble those of myasthenia gravis. In 35 cases of verified myasthenia gravis no patient has had a negative score. For testing purposes it is well to use a standard amount of prostigmine methylsulfate, as suggested by Viets and Schwab. One cubic centimeter of a sterile aqueous solution containing 0.0015 Gm. of prostigmine methylsulfate and 0.0006 Gm. of atropine sulfate should be injected subcutaneously or intramuscularly. The atropine serves to overcome the intestinal cramps which occasionally appear in some patients as a result of the parasympatheticotonic action of prostigmine salts.

The availability and simplicity of this test should make it possible to avoid errors of diagnosis and to institute proper and early treatment.

## SUMMARY AND CONCLUSIONS

Two cases of myasthenia gravis in which unilateral ptosis was the main presenting neurologic sign are reported.

The apparent similarity to neurosyphilis and to organic palsies of the third nerve is pointed out, and caution is urged regarding faulty diagnosis leading to erroneous treatment.

A simple pharmacologic test employing prostigmine methylsulfate is advocated as a diagnostic divining rod to differentiate the earliest signs of myasthenia gravis from those of other conditions simulating it.

# FUSIONAL MOVEMENTS IN PERMANENT STRABISMUS

## A STUDY OF THE ROLE OF THE CENTRAL AND PERIPHERAL RETINAL REGIONS IN THE ACT OF BINOCULAR VISION IN SQUINT

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## I. INTRODUCTION

### 1. PHYSIOLOGIC BASIS OF BINOCULAR VISION

Concomitant strabismus is never a purely mechanical anomaly. Innervational factors play a large part in its causation, and the faulty position of the eyes is always accompanied by a severe disturbance of the sensorial functions and the binocular cooperation of the eyes.[1] It would be wrong, however, to assume that all sensorial cooperation between the two eyes ceases when manifest concomitant strabismus sets in. A more or less rudimentary sensorial cooperation can be demonstrated in all cases.

The sensorial behavior of the eyes in normal and in anomalous conditions has been studied thoroughly, and there is today a good general understanding of the visual act in squint. But many phases remain unexplained and many questions unanswered. The great biologic significance of the visual act in squint and its importance for the diagnosis and treatment in clinical cases warrant further investigation. At the Dartmouth Eye Institute there has been an opportunity to analyze thoroughly a large number of cases of concomitant strabismus. Some results obtained in a selected group in which a new method of examination was used are reported in this paper.

In dealing with the visual act in squint I must state my point of view relative to the basic concepts and definitions of binocular vision. This is necessary because these concepts indicate the starting point of the investigations and the premises for the conclusions drawn from the results. In the present paper, concerned with the fusional movements

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1. Bielschowsky, A.: The Etiology of Squint, Am. J. Ophth. **20**:478 (May) 1937.

in concomitant strabismus, I shall merely enumerate these concepts. In another paper I shall treat them in more detail and shall also discuss the recent objections raised to them.

According to the older, so-called projection theory of binocular vision, the visual impressions have no innate spatial quality. The spatial quality is acquired by experience, and the visual impressions are as if projected into space along the objective lines of direction, i. e., the lines connecting a point in space with its image on the retina. Thus a binocularly seen point in space is localized at the intersection of the lines of direction coming from the two eyes. This theory is erroneous, and it would not be mentioned here if it were not for the fact that it can still be found both in textbooks and in scientific papers written by specialists in the field.

The only theory which explains all experimental evidence satisfactorily is that derived from the methods of "exact subjectivism" (Tschermak). According to this theory the relative localization in space is determined by innate subjective values, inherent in each retinal element.[2] These inherent spatial values are manifested in the subjective visual direction, belonging to each retinal element. The existence of these subjective visual directions causes points in space to be localized according to the spatial values of the stimulated retinal elements and not according to their objective position in space (i. e., their lines of direction). The word projection should therefore be dropped entirely from the discussions of binocular vision, in order that confusion may be avoided.

Binocular single vision is based on the simultaneous stimulation of elements in the two retinas having the same innate visual direction, or, as it is usually called, a common visual direction. Such elements of the two retinas are designated as corresponding retinal points and represent the center of retinal areas (Panum's areas[3]) which have the same relative position in the two eyes. Corresponding retinal elements provide the basis for the normal sensorial relation. This normal retinal correspondence is innate and stable in a normal person and a prerequisite for full binocular vision.

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2. I am dealing here only with the relative, or directional, localization of points in space, i. e., the localization of object points relative to each other. The position in space of object points relative to the body of the observer, that is whether they appear to the right or the left of the sagittal plane, above or below the visual plane, nearer or farther, is determined by the absolute, or egocentric, localization. Only the relative localization is determined by innate qualities of the retinal elements. The egocentric localization is determined largely by empiric factors.

3. Ames, A., Jr.; Ogle, K. N., and Gliddon, G. H.: Corresponding Retinal Points, the Horopter and Size and Shape of Ocular Images, J. Optic Soc. America **22**:551 (Oct.) 1932.

The foveas of the two eyes are the best example of corresponding points. In primary position their common visual direction lies, as a rule, in the median plane of the head. In the clinical examination of the sensorial relation of the two retinas one determines the relations of the two foveas and infers that one's findings for the foveal regions hold good for the retinas as a whole. It will be seen that this generalization is not always permissible.

But normal correspondence, although stable in a normal person, is not a rigid point to point relation which can never be altered.[4] The eyes possess a high degree of adaptability; the retinal correspondence is flexible; if need be, retinal elements which are normally noncorresponding acquire a common subjective visual direction and maintain it as long as it is of benefit. This acquisition of a common subjective visual direction by retinal elements which formerly had different visual directions is the essence of anomalous retinal correspondence.[5]

Binocular single vision is not produced solely by stimulation of corresponding retinal elements. Noncorresponding, or disparate, retinal elements can also convey a single visual impression. The stimulation of horizontally disparate retinal elements adds a new quality to the visual impression, the quality of depth: Within limits the stimulation of horizontally disparate retinal elements produces stereopsis or depth perception (as opposed to the interpretation of depth based on perspective clues).

However, at least certain parts of the retinal images must fall on corresponding retinal elements, and in order to overcome an undue disparity caused either by the position of the eyes or by the position of the images on the retina, corrective movements of the eyes take place which are known as fusional movements. These movements are psychooptical reflexes[6] that can be neither produced nor stopped voluntarily; but they do not take place without the participation of higher psychic functions, notably attention. Fusional movements are produced by tonic innervations; they develop slowly and increase until a certain constant level of the innervation is reached. This level is maintained as long as the fusional stimuli are active and unchanged. After the removal of these stimuli, the fusional innervations do not cease immediately and

4. In speaking about the eyes in general I refer to the whole visual system, including all nervous pathways and centers linked to the peripheral receptor organ.

5. Bielschowsky, A.: Application of the After-Image Test in the Investigation of Squint, Arch. Ophth. **17**:408 (March) 1937. The fact that the angle of anomaly is not always adapted to the angle of squint has various reasons which will not be discussed here.

6. Hofmann, F. B., and Bielschowsky, A.: Ueber die der Willkür entzogenen Fusionsbewegungen der Augen, Arch. f. d. ges. Physiol. **80**:1, 1900.

abruptly—they fade out gradually; a residue of this innervation can frequently be demonstrated for a considerable period.

Fusional movements can be elicited only by adequate sensorial stimuli. These stimuli (disparate identical images) may be applied either to the retinas as a whole or to central or peripheral retinal portions only, but to be effective they must stay within certain limits. These effective limits of disparity are known as fusional amplitudes. The fusional amplitudes differ for the various fusional movements (convergence, divergence, positive and negative vertical divergence) and vary greatly not only from person to person but in the same person when tests are made at different times. If an observer is tired or does not focus his attention on the fixated object, the range of his fusional movements is considerably smaller than if he is rested or gives his undivided attention to the fixated object.

The presence of fusional amplitudes is a requirement for the presence of stereopsis. From this it has been concluded that a person who shows fusional movements necessarily has depth perception. It will be seen that this conclusion is not correct.

### 2. SENSORIAL SYMPTOMS OF CONCOMITANT STRABISMUS

Amblyopia ex anopsia, suppression, alternating uniocular vision and anomalies of retinal correspondence represent the sensorial symptoms of concomitant strabismus. With but few exceptions they are found in all cases, singly or combined. It is not really proper to designate these symptoms as sensorial disturbances. To be sure they are deviations from the normal and as such are pathologic; but they actually constitute an attempt of the eyes to make the best of their abnormal position by adapting themselves to the changed mechanical condition.[7] The sensorial symptoms of concomitant squint, therefore, must be considered as restitutional rather than pathologic processes. This is evidenced by the fact that the symptoms change frequently with changes in the position of the eyes.

The deviation of the lines of gaze from normal, which is the most striking symptom of concomitant strabismus, would be most disturbing if it were not for an adjustment of the sensorial apparatus. This adjustment can be attributed to two tendencies of the visual organ. One is to avoid double images; the other is to retain or restore binocular vision. In normal persons these tendencies cause the aforementioned corrective movements of the eyes.

The urge to avoid disturbing double images is strong. It is not necessarily a conscious effort; it is present even in small children, and

7. Tschermak, A.: Ueber physiologische und pathologische Anpassung des Auges, Leipzig, Veit & Co., 1900.

suppression as well as amblyopia ex anopsia is caused by it. This urge, which has been given the rather clumsy name of diplopia-phobia,[8] has even been regarded as one of the causes of strabismus.

The acquisition of anomalous retinal correspondence offers another means of avoiding double images. At the same time it represents an attempt to achieve binocular vision.

Despite the fact that suppression and anomalous retinal correspondence are useful as long as there is considerable deviation of the eyes, they become a great hindrance to the reestablishment of binocular vision once the angle of squint is reduced to zero or to a value approaching zero. Although the sensorial anomalies may change in amount and direction, they nevertheless remain, either because they have a faulty anatomic basis[9] or because they have become deeply rooted habits, and it is often difficult or impossible to eliminate them.

In cases of monocular concomitant strabismus in which one eye shows a high amblyopia that cannot be remedied by occlusion of the better eye or by orthoptic exercises, a satisfactory cosmetic result is all that can be achieved therapeutically. Such cases will not be considered in this paper. In other cases both eyes, when tested separately, have normal or approximately normal visual acuity, and it is aimed to achieve both a cosmetic and a functional result.

### 3. PURPOSE OF PRESENT STUDY AND SELECTION OF PATIENTS

When a small residue of the former angle of squint remains after a successful muscle operation, the patient may regain binocular vision if the following conditions are fulfilled. He must have neither a high amblyopia of one eye nor suppression, but he must have normal retinal correspondence and be able to perceive simultaneously and to fuse the visual stimuli reaching both the center and the periphery of his retinas: His behavior must be identical with that of a normal person with heterophoria. If these conditions are not fulfilled, the patient will not regain binocular vision; and, indeed, only in exceptional but theoretically very significant cases does binocular vision set in spontaneously after an operation for strabismus. Even intensive orthoptic treatment after operation is capable of producing this result only in a certain number of instances.

Frequently the reason why binocular vision is not achieved is obvious; anomalous correspondence often cannot be changed to normal, nor can total suppression be done away with. A large group of patients,

8. Van der Hoeve, J.: Operationen an den Augenmuskeln, in Graefe, A., and Saemisch, E. T.: Handbuch der gesamten Augenheilkunde, ed. 2-3, Leipzig, Wilhelm Engelmann, 1922, vol. 2, chap. 12, p. 1589.

9. In that event, of course, they would be truly pathologic.

however, have been and still are puzzling to ophthalmologists. They have a small angle of squint, normal or approximately normal vision in each eye and normal correspondence either permanently or most of the time, yet their binocular vision cannot be restored.

The explanation usually given is that these patients have a congenital absence of fusion. This statement, which is more final than satisfactory, often seems inadequate. I therefore examined such patients by means of a new method and attempted to analyze the type of disturbance preventing binocular vision. Although one is not always able to discover the cause, the new method allows one in every instance to establish the seat of the disturbance and to determine in detail the extent to which and the way in which the two eyes cooperate. This in itself is a decided step forward.

This study yielded so many interesting results that it seemed justifiable not to restrict the investigation exclusively to the type of patients mentioned. The subjects selected all had manifest convergent or divergent strabismus with an angle as great as 12 arc degrees; only a few had a larger angle of squint. Some of the patients were never operated on; in others the angle of squint had been reduced by operation. They had equal or nearly equal visual acuity in the two eyes, the vision of the poorer eye never being less than 20/25. All had shown normal as well as anomalous correspondence at some time, but in most one type prevailed to such an extent that they could be classified as having either normal or anomalous correspondence. Most of the patients were between 10 and 25 years of age. A total of 75 patients of this type were examined in the last two and a half years.

In the present paper the results obtained are reported so far as they relate to the presence or absence of fusional movements in cases of permanent strabismus.

## II. INSTRUMENTATION AND METHODS OF INVESTIGATION

Regional differences in the sensorial behavior of the retinas represent one of the great difficulties in the study of the visual act in squint. Suppression is as a rule confined to specific retinal regions, and the selective stimulation of various retinal parts may yield different results as to the sensorial relation. If the retinas as a whole are stimulated, the behavior of one region may interfere with that of the one being examined, and the results may be equivocal. It seemed necessary, therefore, to find a means of investigation which would be flexible enough to allow the selective application of any desired type of controlled visual stimulus to any or all parts of the retinas while permitting observation of the objective position of the patient's eyes throughout

the examination. These requirements are met by the instrument used in the investigation of the response of peripheral retinal regions to fusional stimuli.[10] It was only slightly modified for the purpose of this study.

In essence, the instrument consists of an aluminized screen, a number of projection lanterns provided with polarizing plates and for the patient an adjustable head rest also provided with polarizing material. When the various polarizing plates in front of the patient's eyes and those in front of the projection instruments are properly oriented, the patient will see with one eye the images projected by one group of lanterns and with the other eye the images projected by the other group.

Figure 1 is a schematic drawing of the whole instrumentation. The head rest is fixed on a table; the patient is seated on a stool of adjustable height. His head is so arranged that its median plane is perpendicular to the screen at its center and the eyes are level with the fixation point projected on the screen. The distance from the patient's eyes to the screen is 15 feet (4.5 meters). The

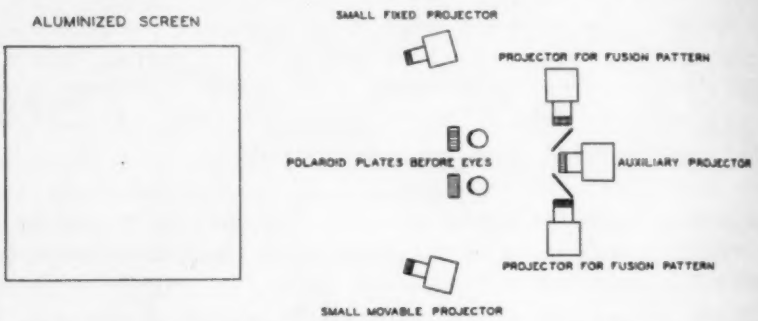


Fig. 1.—Schematic drawing of the instrument. The vertical and horizontal planes of polarization are indicated by vertical and horizontal lines in front of the projection instruments and in front of the observer's eyes.

head rest is provided with apertures which exclude the frame of the screen from the patient's field of binocular vision. Cells are provided to receive refractive or iseikonic lenses or prisms. As a rule, however, the patient wears his own correction in regular spectacle form. In front of his eyes there is a frame containing two square polaroid plates, one polarizing the light in the vertical direction and the other in the horizontal direction. The patient looks with the fixating eye through the center of the corresponding square of polaroid material. The frame pivots around a vertical axis in the patient's median plane, thus allowing one to put either of the polaroid squares in front of either of the patient's eyes. Instead of being mounted in a frame the polaroid material can be mounted in a phoropter head. To the right and to the left of the patient is a modified project-o-chart projector on a floor stand. At the end of the tube of each projector polaroid material is attached, mounted in a ring with a handle, permitting the adjustment of the plane of polarization in any meridian. The slides used in these projectors

10. Burian, H. M.: Fusional Movements: The Role of Peripheral Retinal Stimuli, Arch. Ophth. **21**:486 (March) 1939.

are mounted in the narrow metal frames provided commercially with the projectors; the visual acuity charts which they usually contain are replaced by suitable patterns (dots, lines, circles, etc.). These projectors have a narrow field and are used to project visual acuity charts, test lines, dots and similar figures of restricted size. The position of the projector to the right of the patient is adjustable, but it is fixed during each experiment. The projector to the left of the patient is freely movable in all directions by means of a handle, which is operated either by the examiner or by the patient.

On a table immediately behind and above the patient are three large projection lanterns. One of these is mounted at each end of the table on a movable stand; their beams, which are also polarized, are at first parallel to the patient's frontal plane and are then projected by adjustable mirrors on the screen. The mirrors as well as the projectors pivot around a vertical axis; the projectors can be raised and lowered; they thus form a haploscopic arrangement and the images produced by them can be projected independently on any desired place within the limits of the screen. Their field is large, and they are used for projection of stereoscopic figures or other patterns intended to be fused haploscopically by the two eyes of the patient. The third large projection lantern is also provided with polaroid material. It is placed on the table between and in back of the other two projectors; its beam is projected in the median plane of the patient. It also permits a vertical and horizontal adjustment, but it is fixed during the experiment. It is used for the projection of auxiliary patterns, most frequently for the projection of a tangent scale.

The polaroid material can be easily removed from any of the projection lanterns for the projection of binocularly seen images. All projection lanterns are provided with separate rheostats which permit one to control the brightness of the projected image.

The patient is first examined throroughly by routine methods. If necessary, the proper refractive correction is established, and the visual acuity is measured. The angle of squint for distance vision is determined objectively by the cover test, prisms being used for the compensation of the angle of squint. The double image test (red glass first in front of one eye and then in front of the other, tangent scale at 2.5 mm.) and the after-image test are performed to establish in the usual way the condition of the sensorial retinal relation (retinal correspondence). If indicated, after the angle of squint is corrected with prisms, an attempt is made to elicit fusional movements with vertical prisms. The angle of squint for near vision is determined objectively (cover test and prisms) and if possible subjectively with Bielschowsky's heterophorometer. The binocular cooperation is tested in the stereoscope, the angle of squint being compensated for with prisms. Finally, the rotations are examined, and excessive or deficient movements in the various directions of gaze are noted.

After this preliminary information is collected, the patient is seated on the stool at the projection instrument and his head is properly adjusted. The first part of the examination is a modification of the diplopia test. A tangent scale is projected on the screen by the large

auxiliary projection lantern and a colored dot by the left small movable projector (fig. 2). The scale is visible only to one eye and the dot to the other; as a rule, the test is begun by presenting the dot to the left eye and the scale to the right eye. At the beginning of the examination the dot is placed on the screen so that it coincides with the zero of the scale. The patient is asked whether he sees the dot and the scale simultaneously, whether the dot or any part of the scale appears to be dim and, finally, where the dot is localized on the scale. If he has convergent strabismus with normal correspondence, he will see the dot displaced from the zero toward the side of the eye which sees the dot (uncrossed, or homonymous, diplopia), and the angle subtended by the zero of the scale and the dot will be equal to the angle of squint. If the patient has divergent strabismus with normal correspondence, the dot, with respect to the zero, will appear contralaterally to

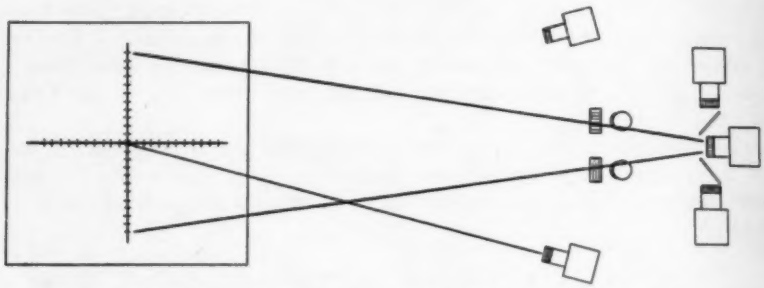

Fig. 2.—Modified diplopia test. A tangent scale and a dot, both seen monocularly, are projected on the screen. The movable projector to the left of the patient can project the dot onto any part of the screen. In the figure it is assumed that the patient sees the dot with the left eye and that the dot is superimposed on the zero of the scale. If the patient has convergent strabismus with normal correspondence and fixates with the right eye, the dot will appear to him on the left side of the tangent scale.

the eye which sees it (crossed, or heteronymous, diplopia), but the distance of the dot from the zero will again be equal to the angle of squint. If a vertical deviation is combined with the horizontal deviation, the dot will appear above or below the row of horizontal figures on the scale. Dissociated vertical divergence [11] is in general easily detected with this arrangement, since the eye that sees the dot receives much less light than the eye that sees the scale. If the patient localizes according to anomalous correspondence, the subjective position of the dot does not agree with the position of his eyes. If the angle of the

11. Bielschowsky, A.: Disturbances of Vertical Motor Muscles of the Eyes, Arch. Ophth. **20**:175 (Aug.) 1938.

anomaly is adapted exactly to the angle of squint, he sees the dot where it is actually located on the screen, as would a person with orthophoria.

When the dot and the zero of the scale coincide on the screen and the patient fixates the zero of the scale, the image of the dot falls on an excentric point of the retina of the deviated eye. The distance, in arc degrees, of this point from the fovea is equal to the angle of squint. Thus one learns from the objective superposition of the dot on the zero of the scale how the patient localizes when the fovea of the fixating eye is stimulated simultaneously with an excentric spot in the retina of the other eye, the distance of the spot from the fovea in arc degrees being equal to the angle of squint. By moving the dot on the screen one can stimulate any other spot on the retina of the deviated eye simultaneously with the fovea of the fixating eye and determine whether this causes any change in the patient's response and if so what the nature of this change is. One is, of course, most interested in finding out what occurs when the dot on the screen is in the line of gaze of the deviated eye, i. e. when the two foveas are stimulated simultaneously. Under these circumstances the reaction of the patient is frequently different from what it is when the fovea of the fixating eye and one excentric point of the retina of the deviated eye are stimulated at the same time. The type and nature of the changes which take place will be discussed later. It is most convenient and instructive to request the patient himself to move the projection lantern until the dot appears to him to be superimposed on the zero. If he is unable to do this, he will nearly always say so of his own accord, giving the reason.

By exchanging the polaroid squares in front of the patient's eyes the whole procedure can now be repeated, the other eye being used for fixation. Differences in the behavior of the eyes are frequently found, according to whether the right eye or the left fixates.

For the second part of the examination the dot and the tangent scale are removed from the screen and identical targets, monocularly seen, are projected by the two large projection lanterns situated at the ends of the table above the patient's head. The target used most frequently was described in the previous paper on fusional movements. It consists of printed matter in the center of which there is a black square (side length 7.5 degrees). By means of the two project-o-chart lanterns two small monocularly seen horizontal test lines are projected —one green and one red. The green one, usually seen with the left eye, is movable; the red one is adjusted at the beginning of the experiment and remains fixed for its duration. At first the two print targets are superimposed on the screen and the two test lines are placed on a level approximately in the middle of the central square, the one seen

by the left eye being the left test line (fig. 3). The patient is now asked to describe what he sees. When his retinal correspondence is anomalous, his visual impression is frequently similar to that received by a normal person, but the test lines may be different in intensity, may be seen alternately or may appear to be displaced. If the green test line seen with the left eye is displaced horizontally or vertically, or both, the patient is requested to move it until it is on a level with and slightly to the left of the red test line seen with the right eye. This

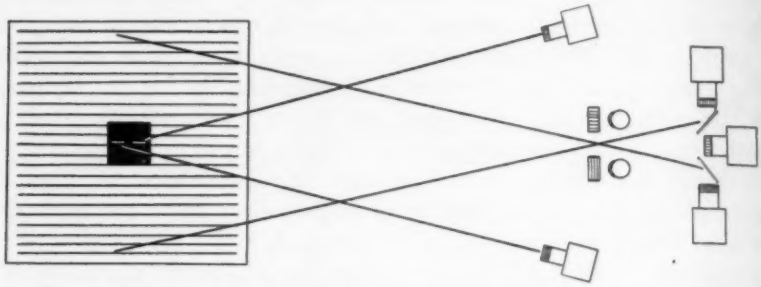

Fig. 3.—Peripheral fusion targets superimposed on the screen. Both targets and the two test lines in the central squares are seen monocularly. The targets are shown in the figure as they would appear to a normal person or to a squinting patient with anomalous correspondence adapted to the angle of the squint.

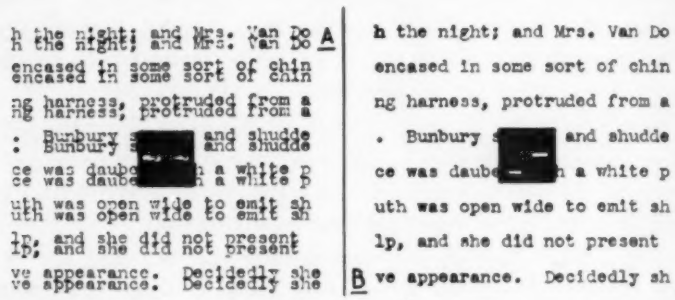


Fig. 4.—Peripheral fusion target displaced vertically. *A*, the appearance of the target on the screen as seen outside the instrument; the print is vertically displaced, and the test lines are opposite each other. *B*, its appearance to a normal observer through the instrument; the print is fused and seen singly, but the test lines are displaced. It is assumed that the fusion target seen with the right eye has been lowered.

is sometimes difficult, but if the patient is able to do it the examiner may proceed to move one of the lanterns projecting the print target upward or downward, thus producing a vertical stimulus to fusion. The appearance of the target on the screen is shown in figure 4 *A*. Normally such a displacement causes a vertical fusional movement of the

eyes, which is evidenced by a change in the level of the test lines. The appearance of the target in figure 4*A* to a normal observer is reproduced in figure 4*B*. The reaction of squinting patients who are able to see the target superimposed and to set the test lines subjectively level is not uniform. They see the print singly either because they actually perform a fusional movement or because they suppress the images of one retinal periphery. Or they see double because they neither suppress nor fuse the images. These three possibilities are differentiated as follows: If the vertical displacement of one of the print targets causes no diplopia, and if there is, at the same time, a displacement of one of the test lines in proper amount and direction, the examiner is sure that the peripherally seen print is actually fused and that the eyes have performed a fusional movement. If the print remains single after the vertical displacement of one target but the relative position of the test lines is unchanged, then there has been no fusional movement of the eyes; the visual impression of one retinal periphery is suppressed. If the displacement of the print causes diplopia, the test lines remain unchanged and there is obviously neither suppression nor fusion.

It is necessary to be alert and critical in performing the described tests, and the examiner must have a certain amount of experience in order not to arrive at erroneous conclusions. It is frequently difficult for the patient to keep the two test lines on a level, and one has to guard against confusing irregular movements of the test lines with the movements indicating a change in the direction of gaze caused by fusional stimuli. Another factor which may mislead the examiner is the rapid alternation which some patients show and which may simulate binocular vision. The patient may report that he sees the print clearly and singly and that the test lines have changed their relative position. But on closer examination one quickly finds that he is comparing not the two test lines but rather each test line with the print of the corresponding side. The patient who shows rapid alternation never sees the two test lines at the same time. He sees first the target visible to one eye, with the test line in the central square, and then the target visible to the other eye, with its test line. Since the print is actually raised or lowered on one side independently of the corresponding test line, this line is now opposite another part of the printed matter, while the test line seen with the other eye has not changed its position relative to the print on its side. By comparing the test lines with the print in monocular observation, the patient comes to the conclusion that one test line is now higher or lower than previously. This may create the false impression on the part of the examiner that the patient has actually performed fusional movements. To prevent such a mistake he must question the patient constantly, making sure that he sees the

test lines simultaneously and warning him to compare the lines with each other and not with the print. In fact, it is best to advise the patient to disregard the print and to concentrate on the test lines.

The best proof that fusional movements have actually taken place is the occurrence of a lag of the fusional innervation after the stimulus has been removed. It was mentioned in the introduction that fusional movements have a tonic element and therefore do not cease immediately with the cessation of the stimulus. This holds true also for the fusional stimuli applied to the retinal peripheries. If the test lines appear to be level at the beginning of the experiment and then to be displaced according to the displacement of the fusional targets, they will not return immediately to their initial level position when the print targets are again superimposed. It takes a certain time, the amount depending on the duration of the fusional stimulation, for them to regain their initial position. There is no doubt that a true fusional movement has been

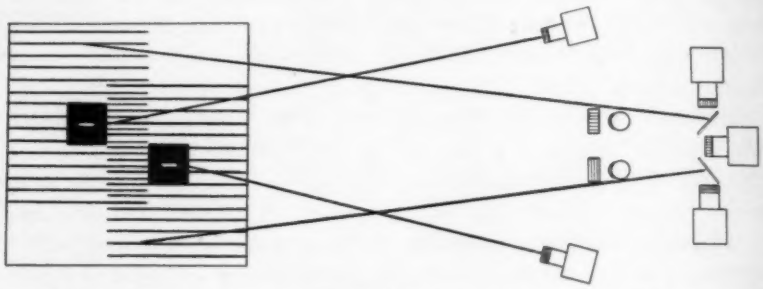

Fig. 5.—Peripheral fusion targets displaced according to the angle of squint of a patient with convergent strabismus and positive vertical divergence who fixates with the right eye. If the patient has normal correspondence the targets will appear to him as the targets in figure 3 appear to a normal person.

elicited by displacement of the print targets when such a lag can be demonstrated.

The next step in the examination is to project on the screen the print targets not superimposed but separated according to the patient's angle of squint. If one is dealing with convergent strabismus the targets are crossed; if the strabismus is divergent their position is uncrossed. At the same time, a possible vertical divergence is equalized by raising or lowering one of the targets. The centers of the two black squares are both now in the lines of gaze of the two eyes. The test lines are also displaced, and the green test line, seen with the left eye, is put in the center of the square seen with that eye; the red test line, seen with the right eye, is put in the center of the square seen with the right eye (fig. 5). Again the patient is asked whether he sees singly and whether he can arrange the test lines on a level. When anomalous

correspondence is firmly established there will usually be diplopia; when there is normal correspondence there is as a rule single vision. According to whether or not the peripheral visual impressions of one eye are suppressed, there will be either diplopia or single vision with or without fusional movements when the print targets are displaced relative to each other in a vertical direction.

If the patient shows anomalous correspondence, the print targets may also be displaced according to his angle of anomaly, and the experiment should be repeated with the targets in that position.

If it is desired to test horizontal instead of vertical fusional movements, the horizontal test lines are replaced by vertical test lines arranged one below the other. The print targets are displaced sideways, and the patient is asked whether the test lines change their position relative to each other in a horizontal direction. However, the fact that voluntary ocular movements tend to interfere with horizontal fusional movements makes this arrangement less precise and less desirable, and as a rule squinting patients have greater difficulties with it than with the arrangement for the testing of vertical fusional movements.

The last group of tests employed is concerned directly with the examination of binocular vision for distance. The test lines are removed from the screen, and, instead of the print targets, stereoscopic slides are projected. These slides are copied from some of the well known sets of stereoscopic cards, and the images may or may not have a horizontal disparity. Some of the slides have graduated disparity of the images, which permits one to estimate the degree of stereopsis. In order to check the reliability of the findings, the polaroid squares in front of the patient's eyes can be exchanged. The disparity is then reversed, and the pictures are seen pseudoscopically and not stereoscopically. All slides can be superimposed on the screen or separated according to the patient's angle of squint or angle of anomaly.

The room is lighted sufficiently so that the patient's eyes can be observed behind the large plates of polaroid during all tests; if necessary, the eyes can be illuminated with a flashlight.

## III. RESULTS

The results obtained are manifold. There are hardly 2 patients the behavior of whose eyes is identical. Each has his own peculiarities and therefore offers new interest. At first the variety of observations was baffling, and only after a large number of patients had been examined was it possible to group the phenomena observed so as to find characteristics common to a number of them and thus draw general conclusions.

The most important results can be summarized as follows: Many of the patients with squint showed a surprisingly high degree of cooperation between the two eyes. In many it was even possible to elicit typical fusional movements, but only by applying peripheral retinal stimuli, i. e. when stimulation of the central retinal areas was avoided. These patients were unable to superimpose visual stimuli reaching the two foveas. On the other hand, patients who were capable of simultaneous perception of the foveal stimuli did not as a rule follow peripheral fusional stimuli.

Patients have three ways of preventing the fusion of images falling on central retinal regions: They suppress the image of one fovea, they change their mode of localization or they change their angle of squint. Patients who do not follow peripheral fusional stimuli either suppress one retinal periphery or see double in the periphery.

It is apparent that there is a certain antagonism between the central and the peripheral regions of the retina, and one can therefore divide patients into two large groups: those whose sensorial disturbance is localized in the central retinal portions and those whose sensorial disturbance is localized in the periphery. There are, of course, persons who belong in a "transitional" group. Some of these have a disturbance of both the center and the periphery; in others anomalous correspondence is so well established that the eyes cooperate both in the central and in the peripheral retinal regions. The majority of the patients, however, can easily be classified in one or the other of the two main groups.

## REPORT OF CASES

I shall now consider a few more or less typical cases. In the first 3 there was permanent spontaneous diplopia. Patients who have this symptom always show normal retinal correspondence in all tests. To this rule there are only a few, but significant, exceptions, which will not be discussed here. If a patient has permanent strabismus and does not suppress images or attempt to restore binocular vision by adapting his sensorial functions to the changed mechanical conditions, he necessarily sees double. However, not all patients of this type show the same behavior, as will be seen from the following examples.

CASE 1.—J. E. R., a man aged 21, has had convergent strabismus of the left eye since the age of 4½ years. With his refractive correction of + 3.25 sph. ⌒ + 1.00 cyl., axis 90 for the right eye and + 2.25 sph. ⌒ + 2.00 cyl., axis 100 for the left, he sees 20/15 with the right eye and 20/20 with the left. When he was first examined the angle of squint was 28 arc degrees; there was normal correspondence in the double image and after-image tests, but the negative after-image on occasion showed anomalous correspondence. A guarded tenotomy of the left internal rectus muscle (September 1938) reduced the convergence to 7 arc degrees. Both the double image and the after-image tests, which have been fre-

quently performed since the operation, have always shown normal correspondence. The patient has permanent spontaneous diplopia but can disregard the double image, and it does not interfere with his normal existence. In the projection instrument he shows normal correspondence: The colored dot is seen in uncrossed double images of 7 to 8 arc degrees, regardless of which eye fixates. Nowhere in the field of vision is there any suppression, and the patient is able to superimpose the dot and the zero of the scale by moving the dot into the line of gaze of the deviated eye. When the print targets for the testing of peripheral fusion are superimposed on the screen, the patient sees all parts of the target double; when they are displaced exactly according to his angle of squint, he has binocular single vision. But there is no trace of fusional movements. As soon as the targets are slightly displaced relative to each other, there is complete diplopia. The same holds true for projected stereoscopic images; they are seen singly if displaced exactly according to the angle of squint, but there is no trace of depth perception; any displacement of the targets causes diplopia.

This case is one of permanent spontaneous diplopia with normal localization of the double image; there is no sign of horror fusionis [12] in any region of the retina, no suppression of either the central or the peripheral visual impressions of one eye and no trace of binocular cooperation. This and other cases of the same type which have been observed are especially instructive, because only in such instances is it justifiable to talk about a complete absence of fusion tendency or binocular cooperation. There is not even an aversion to fusion, as in horror fusionis. Images presented to the patient's two eyes in such a way that they fall exactly on corresponding points are seen singly, but as soon as there is the slightest disparity of the images the patient sees double.

It can be said of such a patient that he actually has two entirely separate sensorial ocular systems; he has a "cyclopean" eye only in so far as the corresponding points of his retinas have common visual directions. But the fact that images that fall on corresponding retinal points are seen singly does not by any means indicate true fusion. This is manifested clearly in a simple experiment. When one holds a pencil or a finger in the median line of the patient's head at some distance from his eyes, he sees the object in uncrossed double images, and as one approaches the object toward his eyes, the distance between the double images decreases. When the object is at the exact intersection of the patient's lines of gaze, he sees only one object, but he says without being asked: "I see one, but they are not really one. I just see two at the same place." Such an experience would be impossible for any one with normal binocular vision. The experiment is successful in the examination of all patients of this type.

12. Bielschowsky, A.: Lectures on Motor Anomalies, Hanover, N. H., Dartmouth College Publications, 1940, p. 46.

What was observed in such patients is of great significance for a thorough understanding of the act of binocular vision. One says that they have normal retinal correspondence, but this is a simplification. It can be claimed only that the corresponding points of their retinas have common visual directions or, differently expressed, that these patients localize images falling on corresponding points in the same direction. A closer analysis shows that a full definition of normal retinal correspondence requires the additional qualification that the visual impression transmitted by retinal elements which have the same visual direction must create a single visual impression allowing no further analysis, i. e. a single mental image which is actually fused. The unification of two images as achieved by patient J. E. R. at the intersection of his lines of gaze is more rudimentary and shows that the presence of innate common visual directions is more primitive than fusion. One gains from the study of this patient not only an enlargement of the concept of normal correspondence but a better understanding of and a convincing argument for the existence of innate common visual directions.

The next case represents a different type of permanent spontaneous diplopia.

Case 2.—J. F. Jr., a 31 year old lawyer, reported that his left eye had turned out since he was 1 year of age. That eye was operated on when he was a child. Ever since he can remember he has had permanent spontaneous diplopia. He wears no glasses. The refraction and visual acuity are: right eye, + 0.75 sph. ⌒ + 0.50 cyl., axis 90 = 20/15; left eye, + 2.00 sph. ⌒ + 0.50 cyl., axis 105 = 20/20. With this correction there is divergent strabismus of the left eye of 5 arc degrees, with normal correspondence in the double image and after-image tests and in the test with the dot and scale in the projection instrument. The patient is unable, subjectively, to superimpose the dot and the zero of the scale; he can approach the dot very close to zero, and then it jumps to the other side. It can be observed that this slight change in the position of the dot around the zero is due to small movements of the eyes: The patient shows the typical behavior of so-called horror fusionis. This behavior applies not only to the central but to the peripheral parts of the retina: The print targets are always seen double, no matter how they are placed on the screen. When they are displaced slowly so as to approach the patient's lines of gaze, the double images seem to come closer together, but small movements of the eyes always prevent their superposition. The same behavior can be demonstrated with any other target.

The comparison of this case with the first is instructive. In both instances there is normal correspondence when the fovea of one eye and a peripheral retinal element of the other eye are stimulated simultaneously; the two images are localized in different directions and their separation is equal to the angle of squint determined objectively. In the first instance the simultaneous stimulation of two corresponding points, for instance the two foveas, results in a single, although not

actually fused, visual impression. But in the second instance the patient refuses to respond to a simultaneous stimulation of corresponding points. Although this may seem paradoxic, the latter type of reaction represents a higher development of binocular cooperation of the two eyes. In the first case there is not even a primitive cooperation of the two eyes beyond the rudimentary existence of common visual directions, and there is therefore no aversion to simultaneous stimulation of corresponding retinal points. In the second case the possibilities for binocular cooperation are further developed but are somehow defective, and the result is that fusion not only is not achieved but is actively rejected.

Another step toward the establishment of full binocular cooperation is represented by the third case of permanent spontaneous diplopia.

CASE 3.—R. C. B., a youth 18 years of age, who was operated on at the age of 7 for convergent strabismus which allegedly had existed since birth, has now, objectively, a residue of manifest permanent convergence of 7 to 8 arc degrees. Without correction his visual acuity is 20/15 — 1 in the right eye and 20/15 — 2 in the left. He wears no glasses; his manifest refraction is: right eye, + 0.37 sph. ⌒ + 0.25 cyl., axis 180; left eye, + 0.37 cyl., axis 165. He has spontaneous diplopia but is able to disregard the second image entirely. Both the double image and the afterimage test show normal retinal correspondence. Examined with dot and scale he shows uncrossed diplopia of 7 to 8 arc degrees with either eye fixating. The image of the nonfixating eye is fainter than that of the fixating eye, but suppression is not complete. The patient is unable to superimpose subjectively the dot and the zero of the scale. As soon as the dot approaches the line of gaze of the deviated eye (for instance, when it is 6 arc degrees to the right of zero when the left eye sees the dot) the dot "jumps way over on the other side," as the patient characteristically puts it; he then sees the dot at its actual place on the screen; his retinal correspondence is anomalous and adapted to the angle of squint. This occurs every time the experiment is repeated and when either eye fixates. Objectively there is no change in the position of the eyes, and one must conclude that the patient is unable to superimpose the images of the two foveas, owing to a change from normal to anomalous correspondence when the foveal regions are stimulated simultaneously.

When the print targets for the testing of peripheral fusion are superimposed on the screen the patient sees double. There is no suppression or alternation. When the targets are displaced according to his angle of squint he sees singly and follows peripheral fusional stimuli.

With the stereoscope the patient has uncrossed diplopia (normal correspondence); when the angle of squint is compensated for by prisms he has crossed diplopia (anomalous correspondence); he reacts in the same way as when he is tested with the dot and scale of the projection instrument.

With the routine examination the behavior of the patient seems to be similar to that in the first 2 cases: A small angle of squint, good vision in both eyes, spontaneous diplopia and normal retinal correspondence are present in all 3 cases. However, study with the projection

instrument shows that the third case differs materially from the other 2; there is a suggestion of suppression in one eye, there is definite anomalous correspondence when the two foveas are stimulated simultaneously and there are unquestionable fusional movements elicited by peripheral fusional stimuli falling on corresponding peripheral retinal areas. There is no doubt that the cooperation of the two eyes is much farther advanced in this than in the first 2 cases.

It is of interest that in all 3 cases there is normal correspondence despite the fact that the squint itself started in early childhood or even in infancy. Although it is generally assumed that an early onset of squint results in anomalous correspondence, it has been known that this rule is not followed in all cases. An explanation for the exceptions has never been given but may be deduced from a comparison of the 3 cases under discussion. As has been seen, the existence of common visual directions is a primitive innate condition. If the development of binocular vision stops at this rudimentary stage, the elements necessary for the adaptation of the visual apparatus also remain undeveloped, and anomalous correspondence cannot appear. If the development of binocular vision goes a step further, then anomalous correspondence will be demonstrable under certain circumstances. And if anomalous correspondence is well established, it not only will be present permanently but will allow a high degree of binocular cooperation, such as that in a case which will be reported later.

The next case is in contrast to the ones reported thus far.

Case 4.—F. L., a boy aged 14 years, had shown two years previously, when he was first seen, alternating convergent strabismus of 22 arc degrees with 3 to 4 arc degrees of positive vertical divergence. He showed anomalous correspondence in the double image and after-image tests. The strabismus was first noticed when he was 4 years of age, and at that time he received his first pair of glasses. Refraction and visual acuity are: right eye, + 2.00 sph. ⊃ + 1.75 cyl., axis 15 = 20/20 + 1; left eye, + 2.00 sph. ⊃ + 0.50 cyl., axis 90 = 20/15. A guarded tenotomy of the left internal rectus muscle reduced the angle of squint to 6 arc degrees. Since the operation the patient has always shown normal correspondence in the double image and after-image tests. Examination with the projection instrument reveals normal correspondence in the test with the monocularly seen dot and scale; with either eye fixating the patient has uncrossed diplopia of 6 arc degrees and 1½ to 2 arc degrees of positive vertical divergence. He is able without difficulty to superimpose subjectively the dot and the zero of the scale by bringing the dot into the line of gaze of the deviated eye; there is no trace of central suppression, no alternation and no change in the angle of squint or the mode of localization. This aroused the suspicion that he might have spontaneous diplopia, and, when asked, he admitted that he saw double "whenever he paid attention to it." When the print targets for the examination for peripheral fusion are superimposed, he sees the center double and occasionally also the print; when the targets are displaced according to his angle of squint, he sees singly. A relative displacement of the targets in any direction does not cause any change in the visual impression.

The test lines remain in their position, and the print continues to be perfectly clear. This proves that the patient suppresses completely the peripheral visual stimuli reaching one eye.

The findings in this case are typical. The images falling on the two foveas can be superimposed without difficulty, but there is no response to peripheral fusional stimuli, owing to the suppression of the images of one retinal periphery. This suppression is most marked when corresponding peripheral areas are stimulated. In the previous case, in which peripheral retinal stimuli are effective, the patient is unable to superimpose the images falling on the two foveas. This previously mentioned apparent antagonism in the sensorial behavior has been seen time and again and is one of the noteworthy observations of this study.

At times, however, one finds that there is complete suppression of all visual stimuli reaching the retina of one eye.

CASE 5.—R. A. R., a boy 16 years of age, has had divergent squint since infancy; it is alleged that the squint is much less marked now than previously. He has never been operated on. He has worn glasses for the last four or five years. The refraction and visual acuity are: right eye, + 1.00 sph. = 20/20; left eye, + 1.00 sph. = 20/20. There is an alternating divergent squint of 10 to 12 arc degrees. As a rule the patient localizes according to normal correspondence; rarely, according to anomalous correspondence. The after-image test shows normal correspondence for the positive and anomalous correspondence for the negative after-image. In the projection instrument there is always normal correspondence when the dot is placed objectively at zero. When the patient is asked to move the dot and to superimpose the dot and the zero of the scale subjectively, alternating uniocular vision and anomalous localization set in when the dot reaches the line of gaze of the deviated eye. With the peripheral fusion target there is strictly alternating uniocular vision irrespective of the position of the targets on the screen; there is always complete suppression of the periphery as well as of the central parts of the retina of one eye.

Suppression of the images of only one periphery and subsequent lack of peripheral fusional stimuli can be found also in cases in which anomalous correspondence prevails.

CASE 6.—J. A. F., a youth 17 years of age, has had convergent strabismus of the left eye since the age of 1 or 2 years. He has never been operated on but has worn glasses since the age of 2 years. His refraction and visual acuity are: right eye, + 7.00 sph. ⊃ + 1.50 cyl., axis 90 = 20/15; left eye, + 7.00 sph. ⊃ + 1.50 cyl., axis 90 = 20/20 — 1. With this correction there is convergent strabismus of the left eye of 7 arc degrees; the double image test shows anomalous correspondence virtually adapted to the angle of squint (1 arc degree of uncrossed diplopia); infrequently there is normal correspondence. The after-image test always shows normal retinal correspondence. In the stereoscope there is alternating uniocular vision; the alternation is not spontaneous; the patient must voluntarily shift from one eye to the other. With the projection instrument there is always anomalous correspondence; the angle of anomaly is adapted to the angle of squint in every position of the dot, and the patient can therefore superimpose the dot and the zero

of the scale subjectively, although there is frequently alternating vision. When the peripheral fusion targets are superimposed on the screen, the patient sees singly and localizes the test lines according to anomalous correspondence; there is no trace of fusional movements, owing to suppression of the images of one periphery. When the targets are displaced according to the patient's angle of squint there is either complete alternation or double vision, with anomalous localization adapted to the angle of squint.

If there is no suppression of the peripheral visual impressions, the eyes of patients whose correspondence is prevailingly anomalous follow peripheral fusional stimuli. This is shown by the following example.

CASE 7.—N. J. L., a girl 11 years of age, had permanent convergent strabismus of 28 arc degrees, with anomalous correspondence in the double image test and normal correspondence in the after-image test. The squint was first noticed when she was 2 years of age. Refraction and visual acuity are: right eye, +2.50 sph. = 20/20; left eye, + 3.00 sph. = 20/20. A guarded tenotomy first of the left and then of the right internal rectus muscle reduced the angle of squint to 3 or 4 arc degrees. In the projection instrument there is always anomalous correspondence (4 to 5 arc degrees of crossed diplopia) when the dot is superimposed objectively on the zero of the scale. The patient is unable to superimpose dot and zero subjectively, because as soon as the dot is moved into the line of gaze of the deviated eye, normal correspondence sets in; in that position there is a frequent change between normal and anomalous correspondence, but binocular triplopia has never been observed. In using the print targets the patient experiences considerable trouble in lining up the test lines, but definite fusional movements can be elicited when the targets are superimposed on the screen. When the targets are displaced according to the patient's angle of squint or angle of anomaly, the eyes do not follow peripheral fusional stimuli; there is complete diplopia.

In some cases of strabismus with anomalous correspondence, the adaptation of the sensorial visual apparatus to the mechanical condition is almost complete. This will be seen from the next case, which is the last to be reported in this paper.

CASE 8.—C. S. F., a boy 16 years of age, in whom a turning out of the left eye was noticed when he was 6 or 7 years of age, four years ago was given a stereoscope and cards, which he used regularly but without supervision. He does not wear glasses. His uncorrected visual acuity is: right eye, 20/15 —2; left eye, 20/15 — 2. The manifest refraction is — 0.50 cyl., axis 90 for each eye. The patient has manifest divergent strabismus of 16 arc degrees but prefers the right eye for fixation. He has never had spontaneous diplopia. In the double image test as well as in the after-image test there is anomalous retinal correspondence. He shows anomalous correspondence also with the projection instrument; there is crossed diplopia of 4 or 8 arc degrees, according to whether he fixates with the left eye or the right. There is no alternation or suppression in the field of fixation, and the angle of anomaly remains the same wherever the dot is moved; the patient is able to superimpose the dot and the zero of the scale subjectively. When the print targets are superimposed on the screen, or crossed up to 8 arc degrees, the patient follows perfectly peripheral fusional stimuli in the horizontal and vertical

directions, with the typical lag of innervation. At times he does this even when the targets are diverged 1 or 2 arc degrees, but there is always complete diplopia when the targets are diverged beyond 2 arc degrees as far as the patient's angle of squint. Simple stereoscopic images are fused when superimposed or crossed to 8 arc degrees, but there is no depth perception; the patient suppresses the disparate image of the left eye. When the targets are displaced according to the angle of squint, there is diplopia.

This is a striking example of the high degree of binocular cooperation which a patient with well established anomalous correspondence is able to achieve. He not only follows peripheral fusional stimuli but does so even within a certain range (crossed horizontal disparity of the targets from 0 to 8 arc degrees). However, he has no stereopsis. It is possible that the unsupervised use of a stereoscope over a period of four years may have contributed to the development of the condition.

## IV. CONCLUSIONS

Certain conclusions concerning the development of binocular vision and the visual act in squint can be drawn from the results obtained in the examination of individual patients.

I shall not discuss in this paper the behavior of the retinal correspondence under the various experimental conditions but shall confine myself to the act of binocular vision in general and more specifically to the fusional movements.

Common visual directions of corresponding retinal points are the most basic element in binocular vision and are unquestionably innate in every one. It is inconceivable that there could be binocular vision without this rudimentary normal correspondence, but its presence does not necessarily mean that there is also binocular vision. The next step in the development of binocular vision is the acquisition of the ability to fuse images falling on corresponding retinal points into a single visual impression. At the same time there must develop the faculty of performing small corrective ocular movements of opposite direction, so as to bring disparate images on corresponding retinal elements (fusional movements). Finally, for the highest degree of binocular vision to be present an additional factor must develop, the stereoscopic function of horizontally disparate retinal elements.

There is no one with two normal eyes who does not have common visual directions of corresponding retinal elements. Few persons stop at that stage; most persons acquire a much higher degree of binocular cooperation. If strabismus appears, the visual act depends on the stage of development of binocular vision. The patient does not lose the inborn or acquired binocular cooperation present before the onset of the squint,

but certain modifications take place.[13] In fact, he is able to adapt himself sensorially, often to a remarkable degree, to the abnormal mechanical conditions. But he does not show the last refinement of binocular vision; he has no stereopsis. Indeed, no trace of stereopsis could be detected in any of the patients examined, no matter how the experimental arrangement was modified, and I have failed to find in the literature any case of strabismus in which there was stereopsis. It is of interest that fusional movements apparently are more primitive than stereopsis; as was pointed out in the introduction, it is generally assumed that the presence of fusional movements implies that the patient has stereopsis. However, it is evident from the findings of this study that fusional movements can exist without stereopsis, although there can be no stereoposis without fusional movements.

It is in itself a significant finding that fusional movements do exist in cases of concomitant strabismus.[14] But it is still more interesting that it could be shown in which cases and under what conditions these movements occur. Fusional movements elicited by peripheral retinal stimuli can be found only in patients who have a sensorial disturbance of the central parts of their retinas. If there is no central sensorial retinal disturbance, the patient suppresses the images of one retinal periphery. The only exception to this rule occurs when the patient suppresses all images of one retina or has an anomalous correspondence so highly developed that he presents all attributes of binocular vision save stereopsis.

The fact that there is a certain antagonism in the sensorial behavior of the central and the peripheral parts of the retina might be important in orthoptic training in determining the point of departure for the treatment.

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13. It is, of course, probable that the insufficient development of the binocular function may be an etiologic factor in the appearance of strabismus. But I am not stressing this point, since I am considering the facts from a phenomenologic rather than a causal point of view in this paper.

14. Tschermak (in Bethe, A.; von Bergmann, G.; Embden, G., and Ellinger, A.: Handbuch der normalen und pathologischen Physiologie, Berlin, Julius Springer, 1931, vol. 12, pt. 2, p. 961), A. Bielschowsky (Untersuchungen über das Sehen der Schielenden, Arch. f. Ophth. **50**:406, 1900) and C. Adam (Ueber normale und anormale Netzhautlokalisation bei Schielenden, Ztschr. f. Augenh. **16**:110, 1906) denied the existence of fusional movements in patients with strabismus. F. Mügge (Ueber anomale Sehrichtungsgemeinschaft bei Strabismus convergens, Arch. f. Ophth. **79**:39, 1911) found in 3 cases of convergent strabismus with anomalous localization of the double images adapted to the angle of squint that he could move the arms of the amblyoscope from 3 to 10 arc degrees while the patient was apparently maintaining fusion. Mügge's result is more or less accidental. The patients belong, as far as can be judged, in the category of the last patient reported on in this paper, or in group B4 of the listing given hereafter.

Although there is a great variety of findings in the different cases, it is possible to group them schematically in the following way. Most cases fit completely into one of the groups.

### A. NORMAL CORRESPONDENCE

1. There is no sensorial disturbance of either the center or the periphery of the retina; there is single vision when the print targets are displaced according to the angle of squint, and otherwise there is diplopia; the eyes do not follow peripheral fusional stimuli.

2. There is sensorial disturbance of the center of the retina (change in the angle of squint); the eyes do not follow peripheral fusional stimuli; the print targets are always seen double.

3. There is no sensorial disturbance of the center of the retina; there is suppression of the images of one retinal periphery; the eyes do not follow peripheral fusional stimuli in any position of the print targets.

4. There is suppression of the central and the peripheral retinal impressions; the eyes do not follow peripheral fusional stimuli; there is complete uniocular vision.

5. There is sensorial disturbance of the center of the retina (change in mode of localization, suppression); when the print targets are separated according to the angle of squint there is single vision and the eyes follow peripheral fusional stimuli; otherwise there is diplopia.

### B. ANOMALOUS CORRESPONDENCE

1. There is no sensorial disturbance of the center of the retina; there is suppression of the images of one retinal periphery; the eyes do not follow peripheral fusional stimuli.

2. There is suppression of the central and the peripheral retinal impressions; the eyes do not follow peripheral fusional stimuli; there is complete uniocular vision.

3. There is sensorial disturbance of the center of the retina (change in mode of localization, suppression); the eyes follow peripheral fusional stimuli when the print targets are superimposed on the screen (anomalous correspondence adapted to the angle of squint) or displaced according to the angle of anomaly; otherwise there is suppression, or diplopia.

4. There is no sensorial disturbance of either the center or the periphery of the retina; the eyes follow peripheral fusional stimuli when the targets are displaced within the range of the anomalous correspondence; otherwise there is suppression or diplopia.

## V. SUMMARY

A projection method for the examination of the binocular cooperation of patients with permanent strabismus is described.

About 75 selected patients with permanent horizontal deviation as great as 12 arc degrees and with good vision in each eye were examined. None of these patients had normal binocular vision, but a large number of them followed peripheral fusional stimuli.

It could be demonstrated that patients in whom peripheral fusional stimuli were effective showed as a rule a sensorial disturbance (suppression or change in the mode of localization or in the angle of squint) when the two foveas were stimulated simultaneously; patients who did not follow peripheral fusional stimuli usually did not show a sensorial disturbance of the central parts of the retinas but suppressed the images of one retinal periphery.

Different types of cases are reported, and the implications are discussed which the findings have for the understanding of the act of binocular vision and the visual act in squint.

The members of the Clinical Division of the Dartmouth Eye Institute cooperated in this study, and Dr. Walter B. Lancaster assisted with critical advice in preparing the manuscript. The projection instrument was first developed by Prof. Adelbert Ames Jr., for the study of aniseikonia in patients with heterotropia. The late Dr. Alfred Bielschowsky saw and verified most of the original findings, and the author wishes to dedicate this paper to the memory of his great teacher.

## ABSTRACT OF DISCUSSION

Dr. Walter Henry Fink, Minneapolis: Dr. Burian not only has presented an original approach to the subject of strabismus but has given an insight into a new analysis of the obscure subject of defective binocular vision. There are certain lessons of clinical importance to be learned from his paper.

His contribution is an analysis of the various levels of binocular coordination and the assignment of a more exact role and value to the fusional movements. His method of analyzing binocular defects permits application of a controlled visual stimulus to any or all parts of the retina while the position of the eyes is being observed.

He concedes that his work is introductory and that conclusions cannot yet be drawn. This is logical, because the number of patients examined was limited and there is still a question as to how applicable his work is to the practical approach of the problem of strabismus.

The work offers a possible explanation for some of the numerous variations in results in the treatment of concomitant strabismus. That an explanation is needed is well recognized. For example, one sees patients with strabismus in whom diplopia persists after operation in spite of treatment. One sees, on the other hand, patients in whom binocular unity immediately develops.

It is known that this difference in response is due to variations in the degree of physiologic adjustment of the retina to the abnormal

position of the eyes. It is in this connection that Dr. Burian's paper is of greatest value, because by his method of examination a more detailed analysis is possible of the responses of the retina in the act of binocular vision. He has been able to isolate various portions of the retina and measure the response of a certain area to stimulation. This area, in turn, is compared with other areas, and by this means the site of the disturbance may be discovered. Thus he finds that many of the abnormal responses and antagonisms associated with concomitant strabismus are made evident. He is also able to tell the extent to which, and the way in which, the two eyes cooperate. Because of this better understanding a more detailed analysis of the abnormal binocular state is possible and a more adequate method of correction can be devised.

That Dr. Burian has advanced a logical explanation for abnormal binocular responses seems evident in the light of present knowledge of the physiology of the retina in binocular vision.

It is known that the binocular apparatus adjusts itself to the abnormal condition in concomitant strabismus. There is abundant evidence that the retina attempts to simulate normal conditions, the degree of which depends on the amount of binocular unity at the time of onset of the strabismus.

It is known that fusional movements are essential to binocular vision and are present in cases of strabismus in which a fairly high degree of binocular sensitivity is present.

Some knowledge exists as to the action of the various portions of the retina in relation to binocular vision. It is known that the development of fusion is greatest in the macular region, less in the perimacular region and still less in the area beyond. In normal binocular vision the three degrees of fusion act in coordination but the latter two are subservient to the macular fusion.

It is known that the macular area alone is capable of binocular vision, as in cases of advanced retinitis pigmentosa in which only the macula functions. Likewise, if the macula and the perimacular area are destroyed, as in central choroiditis, the peripheral area is sufficient to maintain a degree of binocular unity.

DR. JOSEPH I. PASCAL, New York: This investigation into the differing responses of macular and perimacular stimulation in the deviating eye of persons with permanent squint is timely and instructive. Dr. Burian is to be congratulated on this excellent piece of research. If patients with squint are classified according to the response of the macula of the deviating eye, they can be divided into two groups. In one group awareness of both macular images and superposition of these can be produced. Oddly, no vertical fusional movements on perimacular stimulation can be produced because of persistent suppression in the deviating eye. The binocular responses resemble normal binocular responses more closely than do those in the other group.

A squinter of this group in the ordinary act of vision suppresses the indifferent stimulus to the macula of the deviating eye. By the indifferent stimulus I mean a stimulus reaching the macula from some object lying accidentally in its line of vision. He also suppresses in the deviating eye the perimacular or peripheral image of the object of attention. When an attentive stimulus. one to which his mind is directed.

as in orthoptic testing and training, is thrown on the macula of the deviating eye, there is awareness of this stimulus, and if the two macular images are compatible they are superimposed. This is exactly what happens in normal eyes. When one looks down the tube of a microscope with one eye, say the right eye, the indifferent stimulus to the macula of the left eye is suppressed. The moment the two eyes look up to fix some object, the attentive stimulus to the macula of the left eye is mentally registered and the two macular images are superimposed. Therefore, as far as macular responses are concerned, a squinter of the first group behaves exactly like a normal person. The one point of difference is the suppression of the perimacular image of the object of attention in the deviating eye.

In normal eyes if the image of the object of attention is artificially displaced to the periphery, there is immediate awareness of this peripheral stimulation and diplopia. In persons with squint the peripheral image is suppressed, and the suppression, being the one characteristic difference between the eyes of this group and normal eyes, becomes more dominant than in the other group of squinters. For this reason, possibly, vertical fusional movements on peripheral stimulation, which are found in the other group, are not obtained in this group. Easy suppression of the peripheral image, or, stated differently, strong mental resistance toward registering a peripheral stimulus, a resistance both deep and extensive, characterizes this group.

In the other group there are three subgroups: (1) patients in whom there is macular suppression of both indifferent and attentive stimuli; (2) patients in whom there probably is macular awareness of both indifferent and attentive stimuli but it is falsely projected, and (3) "in-between" patients, in whom there are macular suppression of indifferent stimuli and an unlearned response to an attentive stimulus, causing ocular movements and a change in the angle of squint for avoidance of an attentive macular stimulus. These three subgroups differ in more than one respect from the normal. They differ also in their macular responses from the normal. For this reason, perhaps, the depth and extent of peripheral suppression are not so marked, and fusional vertical movements on peripheral stimulation are thereby allowed.

# UNILATERAL MICROPHTHALMIA WITH CONGENITAL ANTERIOR SYNECHIAE AND SYNDACTYLY

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This report is based on the findings in 2 cases of unilateral microphthalmia in first cousins, girls aged 5½ and 1½ years respectively. In each the anomaly was associated with anterior synechiae which extended from the lesser arterial circle of the iris to the posterior corneal surface. The corneal site of attachment of the iritic membranes was marked by the presence of a hyaline membrane. In addition, in both cases there was partial syndactyly of fingers and toes.

## REPORT OF CASES

The older child, J. C., aged 5½ years, was brought to the clinic of the New York Hospital for an opinion concerning further plastic operations for webbing of fingers and toes and also for an examination of the eyes. The vision in the right eye was 20/200 unimproved and in the left eye was reduced to perception of hand movements. The left eye was moderately microphthalmic. The center of the cornea of this eye was opaque because of a dense membrane, about 3 mm. in diameter, on its posterior surface, to which broad iritic membranes were attached. There was no coloboma. The retina of the eye could not be visualized. The right eye was of normal size but had three broad iritic synechiae extending from the collaret to a small central glassy membrane attached to the posterior corneal surface. The pupil of this eye could be dilated to about 3 mm. Examination revealed no choroidal coloboma or fundal changes. A thorough examination in the department of pediatrics revealed no other developmental or acquired defects. Psychologic tests showed normal mentality.

A study of the pedigree revealed that the patient's first cousin, L. W., aged 1½ years, had a similar defect in her left eye, with anterior iritic membranes attached to a glassy membrane on the posterior corneal surface, and also had partial syndactyly of fingers and toes. L. W.'s left eye was noticeably smaller than the right; the difference was greater than in J. C. The right eye was entirely normal. In both cases biomicroscopic examination revealed no keratitic precipitates or other evidence of inflammation. As far as could ascertained no other member of the family group had any abnormalities. There was no kinship between father and mother in either case. The mothers of the children were sisters, but the fathers were not related to each other.

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Fig. 1 (J. G.).—The haze in the center of the cornea of the right eye is caused by a membrane on the posterior corneal surface. The left eye shows microphthalmia and a similar opacity at the center of the cornea.

Fig. 2 (J. G.).—*A*, partial syndactyly, with webbing between the third and the fourth digits. Webs between the thumbs and the forefingers were surgically corrected. The scar on the left hand followed an attempt at separation. *B*, partial syndactyly, with webbing between the second and the third toes.

Fig. 3 (J. G.).—*A*, the right eye, showing the iritic membranes and a more translucent hyaline membrane on the posterior corneal surface. *B*, biomicroscopic picture of the right eye, showing the details of the anterior iritic membranes under high power magnification (× 35). *C*, the partially microphthalmic left eye, showing the anterior iritic membranes attached to the hyaline membrane on the posterior corneal surface.

Fig. 4 (L. W.).—Webbing of the toes.

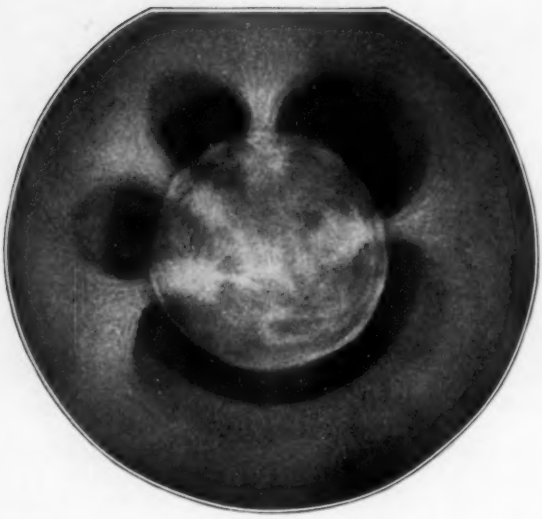

Fig. 5 (L. W.).—The microphthalmic left eye, showing four anterior iritic membranes attached to a membrane on the posterior corneal surface.

COMMENT

It is interesting to speculate as to whether any connection exists between the abnormalities in these 2 cases and those of other syndromes in which ocular alterations are associated with anomalies of the extremities, e. g. the Laurence-Moon-Biedl syndrome,[1] acrocephalosyndactyly and the conditions reported by Biemond,[2] Lohmann,[3] Ratner[4] and Ciotola.[5] The cases reported by Lohmann in 1920 and by Ciotola in 1938 most closely resembled the cases reported here, differing however in some respects. In Ciotola's first case microphthalmia (unilateral) was associated with coloboma of the iris and of the choroid, with partial syndactyly affecting both hands. His second case was one of unilateral microphthalmia with signs of an earlier uveal inflammatory process, unilateral polydactyly and unilateral cryptorchidism. He found no evidence of any endocrine dyscrasia. In Lohmann's cases there were microphthalmia, polydactyly and alterations of the cranium and of the face.

Ciotola, after reviewing all the reported cases of microphthalmia, polydactyly and syndactyly, divided them into two groups. In group 1, which represented the majority, he placed cases in which there were severe skeletal and organic changes and in which the subject was either a fetus or a newborn infant who lived only a few days and presented the characteristics of a monster.

In group 2 he included cases in which there were ocular defects and the skeletal and organic malformations were not so severe and the subject was consequently able to survive. This group was small and included the cases reported by Lohmann and Ciotola; the 2 cases reported here belong in it also. The cases of Sorsby,[6] Biemond[2] and van Bogaert and Delhaye,[7] in which there were uveal coloboma and

1. Biedl, A.: Ueber das Laurence-Biedlsche Syndrom, Med. Klin. **29**:839-840 (June 16) 1933.

2. Biemond, A.: The Laurence-Biedl Syndrome and a Related New Syndrome, Nederl. tijdschr. v. geneesk. **78**:1801-1809 (April 21) 1934.

3. Lohmann, W.: Beitrag zur Kenntnis der reinen Mikrophthalmus, Arch. f. Augenh. **86**:136-141, 1920.

4. Ratner, J.: Beitrag zur Klinik und Pathogenese der Pyknolepsie (zur Begriffsbestimmung der Dienzephalosen), Monatschr. f. Psychiat. u. Neurol. **64**: 283-298 (Aug.) 1927.

5. Ciotola, G.: Microftalmo e malformazione delle dita (sindattilia, polidattilia), Boll. d'ocul. **17**:855-867 (Oct.) 1938.

6. Sorsby, A.: Congenital Coloboma of the Macula, Brit. J. Ophth. **19**:65-90 (Feb.) 1935. Ridley, F., and Sorsby, A.: Modern Trends in Ophthalmology, London, Butterworth & Co., Ltd., 1940.

7. Van Bogaert, L., and Delhaye, A.: Observation d'un syndrome familial nouveau (Biemond) proche de la maladie de Laurence-Moon-Bardet, Bull. et mém. Soc. méd. d. hôp. de Paris **36**:420-425 (July) 1936.

polydactyly but no microphthalmia, might be considered a subgroup. Uveal coloboma when present seems to be associated with fewer and less serious extraocular malformations than is microphthalmia.

To explain the pathogenesis of microphthalmia Picqué [8] advanced three theories: first, that it is connected with a general arrest of development; second, that it is due to a local arrest of development (coloboma *du plancher* or coloboma of the floor), and, third, that it results from the effects of local inflammation, e. g. uveitis, during intrauterine life. Although in some cases there seems to be definite histologic proof of the inflammatory theory, in the main microphthalmia is considered an inherited defect, germinal in origin.

It is apparent that the initial impulse for the production of germinal defects must arise during the early periods of organogenesis, i. e. during the first six weeks. However, it is not inconceivable that an arrest occurring during organogenesis and resulting in microphthalmia may be followed by such aberration as cysts or iritic defects. Considering the frequency of the association of microphthalmia with coloboma and cysts, one might be tempted to assume that there is a definite relation between them and argue that the presence of one defect encourages the formation of the others. Mann [9] stated that the formation of peripheral anterior iritic synechias and glassy membranes is due to a faulty differentiation of the postendothelial tissue before the development of the iris. The appearance of coloboma would indicate an arrest or aberration in development at the rim of the optic cup. Again, one might argue that perhaps these defects act as deterrents to the natural development of the eye and as a result produce microphthalmia. However, such a relation is not borne out by the facts. For example, in 1 of my cases the iritic membranes in one eye were not associated with microphthalmia. Most persons with coloboma show no other ocular defects, and likewise cases of uncomplicated microphthalmia are common in which all parts of the eye were completely formed but the eye did not continue to grow with the rest of the body. One therefore is forced to conclude that aberrations associated with microphthalmia are merely fortuitous and represent earlier or superimposed arrests.

Various theories have been advanced to explain defects in the extremities such as polydactyly and syndactyly. These have involved (1) faulty arrangement and development of either the supplying vessels or the nerves, (2) amniotic bands and (3) the hyperregeneration of Bal-

8. Picqué, L.: Anomalies de développement et maladies congénitales du globe de l'oeil, Paris, G. Chamerot, 1886.

9. Mann,: Developmental Abnormalities of the Eye, New York, The Macmillan Company, 1937.

four.[10] (Balfour, by experimentally removing five toes from feet of lower vertebrates, succeeded in inducing polydactyly. His theory may not be valid for higher animals.) These three theories are highly speculative and in many cases have been disproved. A fourth theory involves endocrine dyscrasias. Lately this theory, especially with relation to the importance of the anterior lobe of the pituitary gland in the development of bone, has been stressed. Many syndromes, e. g. the Laurence-Moon-Biedl syndrome, Marfan's syndrome, the acrocephalosyndactyly syndrome of Alpert and coloboma associated with adiposity (Ratner [4] and Cavallacci [11]), all characterized by malformation of the extremities, have been attributed to dyscrasias of this gland.

To explain malformations of the extremities on the basis of dyscrasias of the pituitary gland it would be necessary to assume that this gland was already formed and functioning during the fourth to eighth week (i. e. during the period in which the mesenchyma acquires osteoblastic function). Since this is questionable, some investigators have advanced the idea that an insufficiency of the maternal gland can react on the fetus. Others have suggested the existence and alteration of a growth center in the same vicinity (mesencephalon). It is difficult to accept this theory when one takes into consideration the fact that dysfunctions of the pituitary gland react on systems rather than on single organs.

The fact that in the 2 cases reported here identical defects appeared in first cousins seems to me to add further evidence in support of the theory that localized congenital malformations result from an arrest or deviation of development occurring in embryonic rudimentary structures because of some unknown defect irregularly dominant in the germ plasm rather than from an individual endocrine dyscrasia. In discussing the frequency with which abnormalities of the hands and feet occur in association with hereditary ocular defects, Sorsby observed: "The fact that in segmented animals the eye and tentacles are homologous, being the sense organs of different segments, may have some significance in this connexion."

The question now arises whether such a combination—microphtalmia with or without iritic defects and deformities of the extremities—should be considered the basis of a syndrome or an incomplete form of other recognized syndromes: e. g. Biemond's, in which polydactyly and coloboma of the iris are associated with arrest in mental development

10. Balfour, F. M.: A Monograph on the Development of Elasmobranch Fishes, reprinted from a series of papers published in the Journal of Anatomy and Physiology, 1876-1878, London, 1878.

11. Cavallacci, G.: Sindromi ipofiso-diencefaliche con microftalmo congenito. Ipotesi sulla loro patogenesi e considerazioni su possibili rapporti con le sindromi tipo Laurence-Biedl ed affini, Arch. di ottal. **44**:1-64 (Jan.) 1937.

and infantilism; or Lohmann's, consisting of a triad, microphthalmia, polydactyly and alterations of the cranium and of the face. In the present state of knowledge it is difficult to know which and how many essential features of a syndrome must be present for the condition to be classified as an incomplete syndrome.

Since both Ciotola's patients and mine are all young children, it is not impossible that such changes as genital adiposity, alterations of the cranium and of the face and mental deterioration will appear after the second decade. If they do it may be possible to establish a closer relation between our cases and those of Lohmann or Biemond. However, as the matter now stands I believe that the aberrations found in Ciotola's cases and in mine (which vary from his in certain details) should be given a special classification.

SUMMARY

1. Two cases are reported of microphthalmia with partial syndactyly of fingers and toes in first cousins. In both, iritic membranes were connected to a hyaline membrane on the posterior corneal surface.

2. These defects, considered hereditary, are explained on the basis of an unknown defect, irregularly dominant, in the germ plasm.

3. It is suggested that the aberrations in Ciotola's cases (microphthalmia, coloboma, syndactyly and polydactyly) and in the 2 reported here should be placed in a special category.

# VERTICAL NYSTAGMUS FOLLOWING LESIONS OF THE CEREBELLAR VERMIS

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AND
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WASHINGTON, D. C.

If one tries to determine the site of a lesion that produces nystagmus, the direction of the nystagmus is of great importance. The appearance of vertical nystagmus in particular is significant, since it usually indicates (apart from rare lesions of the vertical canals) a disease of the central nervous system (Leidler [1]). Clinical experiences (Marburg [2]) indicate that vertical nystagmus usually is caused by a lesion in the cranial part of the vestibular nuclei, and the experiments of Leidler [3] on rabbits also point to the importance of the cranial part of the vestibular nuclei.

Our attention was directed to this problem in a former series of experiments in which we produced bilateral lesions of the vestibular nuclei in a study of the effects of such lesions on the production of optokinetic nystagmus.[4] We noticed that in some of the cats operated on vertical or mixed vertical and rotatory jerks appeared in addition to horizontal or mixed horizontal and rotatory nystagmus, although histologic examination revealed that the lesions were limited to the caudal part of the vestibular nuclei. In analyzing this observation, one has to bear in mind that one must elevate the posterior part of the cerebellar vermis from the floor of the fourth ventricle or perforate parts of the cerebellum if one wishes to place the lesions in the vestibular nuclei. Thus the question arises whether the appearance of vertical eye jerks is due to concomitant lesions of the cerebellum (of the posterior part of the vermis in particular). Unfortunately it is controversial whether cerebellar lesions are able to produce nystagmus, some authors (Bauer and Leidler [5]) denying and others (Holmes [6] and Sachs [7])

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1. Leidler, R.: Pract. oto-rhino-laryng. **2**:86 and 152, 1939.
2. Marburg, O.: Laryngoscope **49**:631, 1939.
3. Leidler, R.: Arb. a. d. neurol. Inst. a. d. Wien. Univ. **21**:151, 1916.
4. Scala, N. P., and Spiegel, E. A.: Tr. Am. Acad. Ophth. **43**:277, 1938.
5. Bauer, J., and Leidler, R.: Arb. a. d. neurol. Inst. a. d. Wien. Univ. **19**:155, 1912.

*(Footnotes continued on next page)*

affirming the occurrence of nystagmus caused by lesions restricted to the cerebellum. Authors who were able to record nystagmic ocular movements in association with cerebellar lesions reported chiefly horizontal movements, while observations on vertical nystagmus seem rare. Thomas [7a] observed vertical nystagmiform oscillations after extirpation of the vermis, without, however, excluding the importance of concomitant lesions, e. g., lesions of the corpora quadrigemina. In view of our aforementioned experiments, it therefore seemed of interest to ascertain whether circumscribed lesions of the posterior parts of the cerebellar vermis (the lobus posterior medianus Sven Ingvar) can induce nystagmic ocular movements, particularly in the vertical direction.

## METHOD

The experiments were performed on 10 cats. The lobus posterior medianus cerebelli was exposed after excision of the posterior atlanto-occipital ligament and of the adjacent part of the occipital bone. By introducing small cotton pledgets between the medulla oblongata and the vermis, the latter was gradually elevated from the floor of the fourth ventricle, special care being taken to avoid a lesion of the fossa rhomboidea. The lobus posterior medianus was then cauterized, while the floor of the ventricle was protected by a small sheet of rubber or cotton. In some experiments only the parts of the lobus posterior medianus were cauterized which could be exposed without separating the vermis from the ventricle. In other experiments the lobus posterior medianus was mechanically extirpated in order to avoid possible by-effects of the cauterization on the medulla oblongata. The operation was performed with the animal under ether anesthesia, so that the effects of the anesthetic would be only fleeting and those of the lesion could be watched as soon as possible after the operation. The eyeballs were observed not only with the head in the normal position but with the animal in side positions and in the supine position (vertex downward). The relation between the head and the trunk was kept constant during examination of the eyes by fixation of the animal on a board and of the head in a Czermak head holder, so that neck reflexes could not interfere. The extent of the lesions was studied macroscopically and in some animals on serial sections stained by Weil's method and with cresyl violet respectively.

## RESULTS

Nystagmus was noticeable immediately or a few hours after the animal awakened from anesthesia. It was vertical with the fast component upward or downward or vertical with a rotatory or horizontal component, or groups of vertical jerks appeared between groups of horizontal jerks. Occasionally the nystagmus was mixed rotatory and oblique. The jerks of the vertical nystagmus were often superimposed

6. Holmes, G.: Brain **40**:461, 1917.

7. Sachs, E.: Diagnosis and Treatment of Brain Tumors, St. Louis, C. V. Mosby Company, 1931.

7a. Thomas, A.: Le cervelet, Paris, G. Steinheil, 1897.

on a vertical deviation of the eyeballs (usually downward, and sometimes downward and lateral). The jerks often appeared in groups separated by pauses. With the head in the normal position the frequency of the jerks usually was low, less than 40 in thirty seconds. In 1 instance only it reached 60 in thirty seconds. Its amplitude was small to medium. In the first twenty-four hours after operation the nystagmus was most pronounced; its frequency distinctly decreased on the second to fourth day, and one week after operation it usually was hardly demonstrable.

The position of the head had an interesting influence on the nystagmus, in that frequency and often amplitude were increased with the head in abnormal positions (the relation between the head and the trunk being held constant, as mentioned). This was often demonstrable if the animal was moved from a normal to a lateral position. It was still more apparent if the animal was turned from the normal to the supine position (with the vertex downward), as shown by the following example.

CAT 5.—On Dec. 1, 1939, at 10:30 a. m. to 11:30 a. m., the lobus posterior medianus cerebelli was exposed and elevated from the floor of the fourth ventricle with the animal under ether anesthesia. The posterior as well as the ventral surface of the lobus posterior medianus was cauterized, while the floor of the fourth ventricle was protected by sheets of cotton.

At 11:55 a. m. there was spontaneous nystagmus, 20 jerks in thirty seconds. The majority of the jerks were downward or downward and to the right. A few were only to the right. The left pupil was larger than the right.

At 12:08 p. m. there was in normal position a nystagmus beating in thirty seconds of 3 times down and 4 times to the right.

With the head and body in the left lateral position (left ear downward) there was a nystagmus beating in thirty seconds of 20 times to the left canthus; some jerks had a downward component.

As 12:20 p. m. there was in the supine position (vertex downward) nystagmus toward the lower lid. In successive thirty second intervals one counted 24, 23, 26 and 24 jerks.

At 12:26 p. m. there was in the normal position nystagmus of small amplitude, a beating in thirty seconds of 1 downward and 1 upward. In the supine position (vertex downward) there were in thirty seconds 24 jerks to the lower lid.

At 12:32 p. m. there was in the right lateral position (right ear downward) a counterclockwise nystagmus, sometimes with a component to the lower lid. In successive thirty second intervals one counted 50, 28 and 40 jerks.

The animal was more excited in the positions associated with increased nystagmus than in the normal position. Returned to the normal position, it showed no nystagmus. On passive movements of the head one felt a slight increase of resistance of the extensor muscles of the neck.

On December 2 there was in the normal position a nystagmus clockwise and upward, of small amplitude. In thirty seconds 2 jerks were counted. In the supine position (vertex downward) there was a clockwise nystagmus of greater amplitude. In thirty seconds 32 jerks were counted. In the left lateral position there was clockwise nystagmus of smaller amplitude than that in the supine position. In successive thirty second intervals one counted 24 and 40 jerks.

In the right lateral position there was a counterclockwise nystagmus of small amplitude. In successive thirty second intervals one counted 6 and 5 jerks.

Autopsy (fig. 1 *A*) revealed destruction of the uvula and nodulus extending into the ventral part of the pyramis and the medial part of the right paramedian lobe. The medulla oblongata and the pons were intact.

As this experiment shows, change of the position of the head influences not only the frequency and amplitude but the direction of the nystagmus. For example, with the animal in a lateral position the jerks are horizontal (parallel to the palpebral fissure), usually away from the lower side but occasionally toward it, or they are rotatory, clockwise in the left lateral position (left ear downward) and counterclockwise in the right lateral position. With the vertex downward, the jerks are directed toward the lower lid, i. e. upward in space. Thus, if in the normal position of the head the nystagmus was toward the upper lid, its direction in relation to the head is reversed; if in the

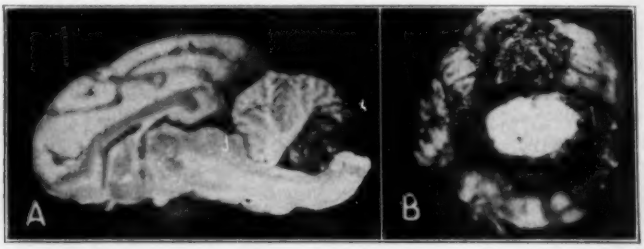


Fig. 1.—*A*, cat 5, sagittal section of the brain. *B*, cat 9, lesion of the cerebellum (posterior view).

normal position it was toward the lower lid, its direction in space is reversed (protocol on cat 9).

After the head had been turned from the normal to the abnormal position, the nystagmus appeared after a latent period of a few seconds. It was exhaustible, particularly several days after the operation, as shown by the diminishing frequency in successive ten second intervals. The following protocol is an example.

Cat 9.—On May 27, 1940, at 11:30 a. m. to 12:15 p. m., the lobus posterior medianus was cauterized. Immediately after operation one observed nystagmus downward with a rate of 15 to 20 jerks in ten seconds.

At 1:35 p. m. there was nystagmus downward and counterclockwise. In successive ten second intervals one observed 9 to 10 jerks.

On May 28 the animal walked with a tendency to fall to the left. In the normal position there was nystagmus downward, sometimes with a component to the left. In thirty second intervals one counted 21 and then 25 jerks. This nystagmus appeared in attacks, and its appearance was associated with excitement of the animal. In the intervals between attacks the eyes were deviated downward; occasionally upward jerks appeared.

In the supine position there was nystagmus to the lower lid. One counted in successive ten second intervals 22, 20, 9, 12, 11 and 12 jerks.

In the normal position the eyes were deviated downward and somewhat to the left. In thirty seconds one observed 2 jerks.

On May 29 one observed in the normal position 3 upward jerks per minute. In the supine position (vertex downward) there was nystagmus to the lower lid. One counted in successive ten second intervals 22, 15, 12 and 10 jerks.

On May 31 the animal aborted, losing three kittens, was in poor general condition and was somnolent. The wound healed normally. In the normal position there were in thirty seconds 10 upward jerks. In the supine position (vertex downward) there was nystagmus to the lower lid, first with large and later with small amplitude. In successive ten second intervals 23, 11, 11 and 7 jerks were counted. In the normal position there were 5 upward jerks in thirty seconds.

On June 1 the animal was dyspneic and very weak. There was a purulent secretion from the nose. In the supine position nystagmus to the lower lid appeared

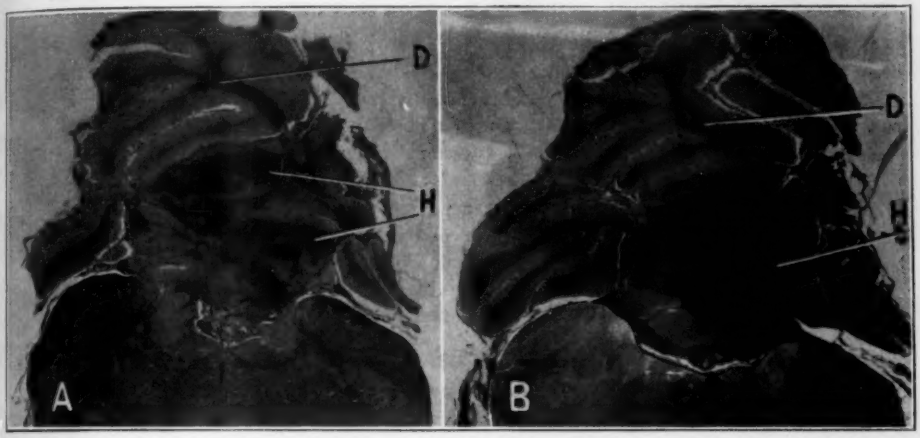


Fig. 2.—Cat 9, frontal sections through the cerebellar lesion (Weil's stain). *H*, hemorrhages; *D*, demyelination.

after a latent period of a few seconds. In successive ten second intervals one counted 19, 11, 7, 4, 3 and 3 jerks. In the normal position there were 6 upward jerks in one minute.

On June 3 the general condition was unchanged. In the normal position one observed 4 or 5 upward jerks per minute. In the supine position (vertex downward) there was nystagmus of small amplitude to the lower lid. In successive ten second intervals one observed 9, 8, 5, 5, and 6 jerks.

The animal died in the night of June 5.

The autopsy (fig. 1 *B*) revealed necrosis of the median and left part of the pyramis and the uvula. The right part of these lobules was partly intact.

Histologic examination of sections through the most caudal levels of the medulla oblongata (with the central canal still closed) showed the surface of the uvula to be covered by necrotic material. There was a focus of demyelination in the lateral part of the nucleus of Goll on one side. Other cranial sections (at the beginning of the fourth ventricle, fig. 2 *A*) showed that parts of the uvula and

pyramis were dispersed with hemorrhages and their remaining parts contained severe damage of the myelin sheaths and the cells. In the tuber there were also demyelination of the central white matter and tigrolysis in the majority of the Purkinje cells. The floor of the fourth ventricle was covered with necrotic material, and the subependymal zone showed necrosis in a few sections taken from above the dorsal nucleus of the vagus and dorsolateral to this nucleus. In these sections one observed hyperemic vessels entering the nucleus of Burdach. With the full development of the nuclei on the floor of the fourth ventricle (fig. 2*B*), the hemorrhages in the uvula and pyramis were observed only in the ventral part of the pyramis and the dorsal part of the uvula. Most of the Purkinje cells in these lobules showed tigrolysis. In the medial part of the left paramedian lobe some Purkinje cells were affected, and zones of demyelination were present in the central white matter of the tuber. The lining of the floor of the fourth ventricle was well preserved. Further cranial sections revealed that the number of preserved cells in the uvula increased, that in the nodulus only a part of the Purkinje cells were affected and that the white matter of these lobules was rather well preserved, while the central white matter of the pyramis continued to show demyelination. The anterior end of the hemorrhages in the pyramis and uvula encroached on the most posterior part of the left nucleus tecti and the white matter in the median line between the two nuclei tecti. Some cells of the nuclei tecti showed a peripheral position of their nuclei; the main part of the nuclei tecti as well as the other deep cerebellar nuclei, however, appeared unaffected. The vestibular nuclei and their fiber systems were histologically intact.

In summary, there were hemorrhages and necrotic areas in the uvula and pyramis, a slighter lesion of the tuber and nodulus and tigrolysis in some cells in the medial part of the left paramedian lobe; the nuclei fastigii were affected in their most caudal parts; the main parts of the deep cerebellar nuclei were well preserved; the vestibular nuclei and their fibers were intact.

As for concomitant lesions of the medulla oblongata, there were found, at most, small punctate hemorrhages or necroses in the most caudal parts of the medulla in levels posterior to the vestibular nuclei (with the central canal still closed) or in the most caudal parts of the calamus scriptorius, e. g. necroses in the nucleus of Goll or in the area of or dorsal to the nucleus dorsalis vagi. In a number of experiments (cats 4, 5 and 6) the medulla oblongata was intact. However, it could be objected that the heat coagulation of the ventral part of the vermis may have affected the floor of the fourth ventricle despite our precautions (see method) and that an impairment of the nuclei did not appear histologically. Control experiments showed that mechanical extirpation of the lobus posterior medianus after elevation of the vermis from the floor of the ventricle was able to produce similar nystagmic phenomena.

If one grouped the cats with vertical nystagmus downward and those with vertical nystagmus upward, the first group showed more extensive lesions than the second. In those with vertical nystagmus downward the lesions affected not only the uvula but a large part of the pyramis (e. g. cats 3 and 9) and sometimes also parts of the tuber,

while in the group with upward nystagmus the lesion affected chiefly the uvula (cat 2) and only slight concomitant involvement of the ventral part of the pyramis (cats 6 and 8) was found. In both groups there were cats with as well as cats without involvement of the nodulus.

It seems necessary, however, to be careful in correlating the extent of the lesion with the direction of the fast component of the vertical nystagmus, since in some cats upward as well as downward jerks appeared; e. g., cat 5 had upward jerks between periods of downward nystagmus while the head was kept in the normal position.

Thus it seems that other factors besides the extent of the lesion and the position of the head play a part in determining the direction of the quick component.

Special attention was paid to the question whether the lesion of the posterior median lobe may be limited to the cortex or must encroach on the deep cerebellar nuclei to cause vertical nystagmus. Histologic examination of serial sections revealed that definite vertical nystagmus could appear although the deep nuclei showed only slight changes (cat 8). The possibility must, however, be borne in mind that the lesion of the cerebellar cortex affected the vessels supplying the deep nuclei (Simonelli [8]) and thus indirectly produced at least a transitory disturbance of their function.

## COMMENT

The nystagmus described is produced by lesions of parts of the cerebellar vermis that send impulses to the vestibular nuclei chiefly by way of fibers to the nuclei tecti and thence by the fastigiobulbar systems. This fact suggests that such nystagmus is due to a release of the vestibulo-ocular reflex arcs from cerebellar inhibition. The existence of a cerebellar inhibition of the vestibular nuclei has already been indicated by experiments of Bauer and Leidler,[5] who showed an overexcitability of the labyrinth on artificial stimulation after ablation of the cerebellar vermis, including the nuclei tecti. Whereas spontaneous nystagmus does not appear in normal rabbits [9] after ablation of parts of the cerebellum,

8. Simonelli, G., cited by Rijnberk, G.: Das Kleinhirn, Ergebn. d. Physiol. **31**:592, 1931.

9. It seems not improbable that the influence of the cerebellum on the vestibular reflex arcs shows species differences. In this connection it is of interest that R. S. Dow (Effect of Lesions in Vestibular Part of Cerebellum in Primates, Arch. Neurol. & Psychiat. **40**:500 [Sept.] 1938) was unable to find increased excitability of the labyrinth in macacus monkeys and chimpanzees after subtotal ablation of the uvula and nodulus; spontaneous nystagmus was observed in his experiments only for a few hours and in exceptional cases. As to the slight nystagmus, the question arises whether cerebellar nystagmus in monkeys and apes is influenced by fixation. The clinical observations of Holmes indicated that in

*(Footnote continued on next page)*

cerebellar lesions may induce the appearance of nystagmus in animals in which one labyrinth has been extirpated and its loss compensated by the development of hyperexcitation of the vestibular nuclei on that side (Démétriades and Spiegel [10]). In such animals the cerebellar lesion apparently releases the vestibular nuclei, which are in an abnormal state of excitation.

The view that the appearance of "spontaneous" nystagmus in the present series of experiments was a release phenomenon may also explain why impulses caused by changes in the position of the head were able to influence the intensity and to a certain degree the direction of the nystagmus.

One may object that the transitory nature of the nystagmus appearing after lesions of the lobus posterior medianus indicates that one deals with a stimulation symptom rather than a release phenomenon. It should, however, be borne in mind that the majority of Luciani's symptoms of "functional exaltation" (e. g. opisthotonos, tonic extensor spasms) last only about one week after ablation of the cerebellum, and Sherrington [11] has pointed out that these symptoms are due to a release of postural mechanisms. Extension of the head and anterior limbs, opisthotonos, may also appear after isolated extirpation of the posterior lobe (pyramis, uvula, nodulus) of the cerebellum (Simonelli [12]). Some of our animals also showed transitorily increased tonicity of the extensors of the neck and a certain tendency to opisthotonos; in the majority of the experiments, however, the vertical nystagmus appeared without a definite increase of tonus in the extensor muscles. This seems understandable, since the inhibition of the extensor muscles is exercised chiefly by the anterior lobe of the cerebellum.

It is of interest that the vertical nystagmus appearing after cerebellar lesions is influenced by changes in the position of the head, as is another

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man nystagmus of cerebellar origin occurs chiefly on fixation, while Leidler [2] called attention to the fact that spontaneous nystagmus is sometimes suppressed by fixation and appears if the fixation is eliminated by proper spectacles. It would be of interest to learn whether the nystagmus which may appear in primates after ablation of the uvula and nodulus is more distinct with the head in abnormal positions, as in our experiments. A. Ferraro and S. E. Barrera (Effects of Lesions of the Juxtarestiform Body [I. A. K. Bundle] in Macacus Rhesus Monkeys, Arch. Neurol. & Psychiat. **35**:13 [Jan.] 1936) observed in Macacus rhesus monkeys after unilateral lesions of the "supramedullary part of the juxtarestiform body" nystagmus to the side of the lesion and after bilateral lesions of this system upward nystagmus.

10. Démétriades, T. D., and Spiegel, E. A.: Ztschr. f. Hals-, Nasen- u. Ohrenh. **19**:250, 1927.

11. Sherrington, C. S., in Schäfer, E. A.: Textbook of Physiology, New York, The Macmillan Company, 1900, vol. 2, p. 884.

12. Simonelli, G.: Arch. di fisiol. **19**:447, 1921.

release phenomenon of the brain stem, decerebrate rigidity. The nystagmus following lesions of the posterior lobe is maximal with the animal in the supine position; similar observations were made in regard to the extensor rigidity of the limbs in decerebrate animals (Magnus and De Kleijn [13]).

SUMMARY

Experiments on cats showed that a cerebellar type of vertical nystagmus exists (besides that produced by lesions of the vestibular nuclei). This nystagmus was observed after lesions of the lobus posterior medianus with the vestibular nuclei and their fiber systems intact. The intensity and to a certain degree the direction are influenced by the position of the head (maximal intensity with the animal in the supine position, with the vertex downward). It lasts only a few days. The phenomenon is considered to be due to release of the vestibulo-ocular reflex arcs from cerebellar inhibition.

13. Magnus, R., and De Kleijn, A., in Alexander, G., and Marburg, O.: Handbuch der Neurologie des Ohres, Berlin, Urban & Schwarzenberg, 1923, vol. 1, p. 465.

# Clinical Notes

## THE CARDINAL ANGLOMETER

EMANUEL KRIMSKY, M.D., BROOKLYN

The cardinal anglometer is, as its name implies, an instrument for the measurement of the status of the ocular muscles not only in the primary position but in any selective direction of gaze at a distance of 13 inches (33 cm.) from the eyes. In addition, this instrument is intended to measure the visual or binocular status for the respective positions of gaze.

The instrument permits one to carry out tests in accordance with established principles and also by careful control and observation of the movements of the eyes. Due provision has been made for:

1. Fixation of the head both in the erect position and in tilted positions.
2. Controlled study of positions and movements of the eyes and of image responses, so that true and anomalous projections can be measured.
3. Studies of the binocular status in definite and selective positions of gaze.
4. Adjustment of the prism or filter holder to the head rest, so that the hands are left free to carry out other operations.
5. Ready selection of bright transparent targets of different sizes, intensities and colors, as well as flashers for studying amblyopia and suppression.

The mechanical features include:

1. A head rest adjustable for the erect position and for tilted positions.
2. A graduated arc, pivoted on the sides.
3. A calibrated light carrier, with:

(*a*) A mechanism by which it can be moved 10 degrees up or down, there being permitted a maximum vertical displacement of 20 degrees between two targets without supplementary prisms (it is to be noted that the calibrations on this instrument are in arc degrees).

(*b*) A marker for 0.75 and 2.5 degree targets respectively.

(*c*) A flasher.

(*d*) A means for selecting transparencies.

4. An indicator for vertical arc displacement to record the amount of upward or downward gaze.
5. A movable base support for the head rest.
6. Adjustable prism and filter holders.
7. A convergence rule attachment.
8. A removable septum.

The anglometer permits such measurements as those of:

1. The gamma angle.
2. Phorias in any selective positions of gaze.

3. Type and amount of manifest squint with regard to both the vertical and the horizontal deviation in any position.

4. Field of monocular fixation.

5. Field of binocular fixation, as well as diplopia fields.

6. Amount and type of diplopia in different fields.

7. Vertical ductions in their minute components—right superduction and subduction, etc., as well as breaking and recovery points.

8. Convergent near point—symmetric and asymmetric as well as maintenance time.

9. True and anomalous projections.

10. Binocular status in relation to tilting of the head.

11. Primary and secondary deviations in cases of paralytic squint.

12. Amount of lateral ductions—although this measurement is less satisfactory than with the phorometric stereoscope.

The anglometer is not used for studies of the visual fields, because mechanically the arc is pivoted on the sides rather than on a fixed center.

While the instrument lends itself to measurement by such familiar methods as the red-green test or simple prism tests, I have found the septum, or modified screen, method the most satisfactory in selected cases, because it permits careful observation of the eyes at all times and provides readings comparable to those obtained with prism and cover. Hence the septum method serves as a quantitative screen test.

My method of examination includes a routine preliminary study, including prism tests at 20 feet (6 meters).

With the anglometer adapted to a fixed distance of 13 inches (33 cm.) I resort first to a routine cover test at the selective positions of gaze and plot the findings on a graph. For the quantitative estimation at these respective positions of gaze, I employ the following methods:

A. The septum method alone—for exophoria or exotropia.

B. The septum and supplementary base-out prism methods—for esophoria or moderate esotropia.

C. The monocular fixation method—for marked esotropia.

D. The false projection method—for paralytic esotropia.

These methods, as well as the underlying principles, were described in detail in my recent exhibit and will form the basis for a separate report.

Both the anglometer and my phorometric stereoscope [1] employ the principle of the septum. There are, however, certain differences between the anglometer and the stereoscope, or synoptophore:

1. The anglometer limits the examiner to a fixed distance of 13 inches (33 cm.). The stereoscope, with its correcting lenses and variable viewing distances, permits one to study the binocular status at different accommodative ranges.

1. Krimsky, E.: The Stereoscope in Theory and Practice, Brit. J. Ophth. **21**:161-197 (April) 1937; Some Newer Developments in Precision Type Stereoscopes, Arch. Ophth. **19**:394-402 (March) 1938.

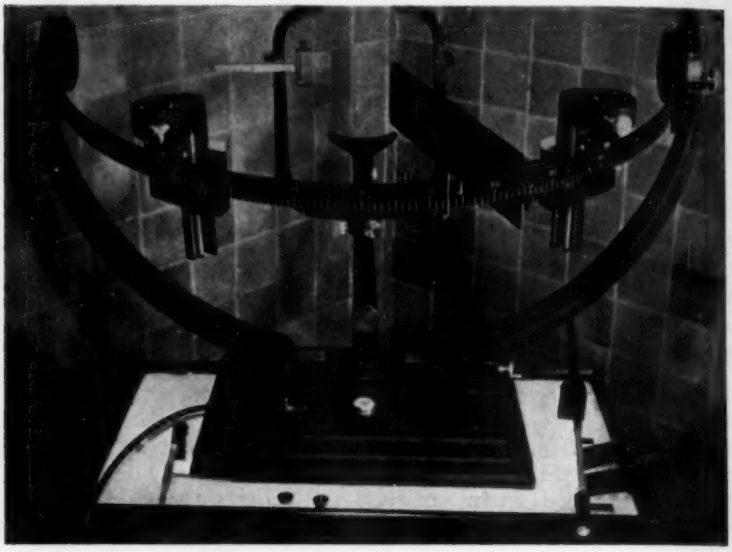

Fig. 1.—The cardinal anglometer.

Fig. 2.—Use of the supplementary prisms in cases of esotropia. In marked esotropia the monocular fixation method without prisms is used.

2. The anglometer permits a study of the peripheral motor fields. The stereoscope limits one to a study of the central fields.

3. The stereoscope is more suitable for study and measurement of lateral ductions in their minute components for near and for far vision, for the study of true and anomalous projections, for stereopsis and for training.

Fig. 3.—The targets set to an angle corresponding to 45 degrees of exotropia and 4 degrees of left hypertropia. In this case there was superposition of images, or true projection.

Fig. 4.—*A*, in this position of gaze there are 10 degrees (20 prism diopters) of right hypertropia and 7 degrees of exotropia. Note that the two targets are on different levels to correspond to such vertical deviation and also that the angular displacement along the arc points to the amount of lateral displacement. The septum was removed for the photograph. *B*, 22 degrees of exotropia and 4 degrees of right hypertropia for this position of gaze, which are plotted on a graph. *C*, the false projection method at this position of gaze. The targets are placed in line with both the true and the false images, and the angle of diplopia is read. In cases of paralytic esotropia no septum is employed.

The stereoscope and the anglometer offer distinct although complementary fields for study.

In the interests of proper word derivation Dr. Walter B. Lancaster suggested the term "cardinal goniometer" and Dr. Percy Fridenberg recommended the term "cardinal angulometer."

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## CORNEAL-SCLERAL SUTURE

SAMUEL G. HIGGINS, M.D., MILWAUKEE

In 1930 I [1] presented before the Chicago Ophthalmological Society a corneal-scleral suture which I had been using for eight years. I have used this suture routinely ever since to close the cataract incision. When it is tied the effect is that of a mattress suture.

Without my knowing of it, mention of a similar suture had been made in Beard's "Ophthalmic Surgery" published in 1914.[2] Stallard [3] sketched a similar suture in the *British Journal of Ophthalmology* in 1938, also, I assume, without being cognizant that such a suture had previously been reported. Beard said:

> Stevenson of Akron makes them both (the two stitches) horizontal, or parallel. The stitches are always placed as near together as will barely admit of completing the corneal section in the interspace. A slight puckering of the cornea denotes that the thread has been properly knotted. A loose suture is without value. It is removed on the third day.
>
> Suturing of the conjunctival flap has also been tried but has not given satisfactory results.

My experience differs from that of Beard. I find that the suture can be removed more easily if the length of thread between the cornea and the sclera is long, about 3 mm., and that its holding ability is as effective when it is long as when it is short. The mattress suture when tied permits the incised cornea to fall on the sclera in a manner resembling that in which the top of a man's cap when buttoned falls on the cap's visor. I do not remove the suture before the end of a week or ten days. When the patient is unruly or when I anticipate slow healing, as in cases of advanced senility or diabetic cataract, I have found no harm in leaving the suture in place three or four weeks.

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Read before the Section on Ophthalmology at the Ninety-Second Annual Session of the American Medical Association, Cleveland, June 5, 1941.

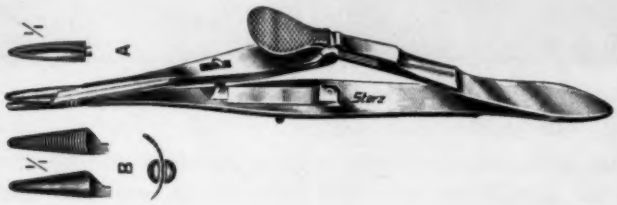
1. Higgins, S. G.: The Closure of the Cataract Incision, Am. J. Ophth. **13**: 1099-1101 (Dec.) 1930.

2. Beard, C. H.: Ophthalmic Surgery, ed. 2, Philadelphia, P. Blakiston's Son & Co., 1914.

3. Stallard, H. B.: Corneo-Scleral Suture in Cataract Extraction, Brit. J. Ophth. **22**:269-273 (May) 1938.

Recently I have placed both stitches in the cornea. As no scarring has taken place, the lower stitch may be near the upper margin of the normal contracted pupil; the upper stitch is in the cornea but near its margin. I allow plenty of room, about 2 to 3 mm., both in the corneal-scleral and in the corneal-corneal placing of the mattress suture for the knife to emerge and 2 mm. for the corneal-corneal stitch. With the corneal-corneal placement one may make the incision with a keratome and enlarge it with corneal scissors. My own experience is an incision with a Graefe cataract knife.

The present popularity of corneal sutures may be attributed in part to improved needles and thread. The first so-called Kalt needles supplied me were, in fact, thin venous needles with rounded sides. An improvement was made when the needles were atraumatically threaded without a needle's eye. After some years of effort the Scanlan Laboratories, of Madison, Wis., have obtained some sharp cutting needles that have been threaded atraumatically with 5 ought black silk thread. These English-made needles are well tempered, so that they do not bend in the resistant cornea as the old Kalt needles often did.




Higgins Kalt eye needle holder, with concave convex grasping surfaces of jaws.

The essential feature is the sharp cutting concave edge with the convex surface flat.

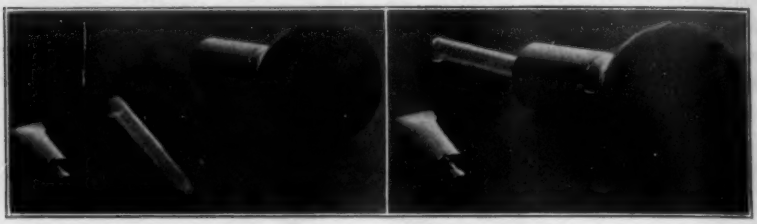
A needle with a small eye is apt to turn in the tip, or jaw, of the usual needle holder. My idea is to place a metal surface on the upper jaw of the needle holder which is curved to approximate the concave side of the needle. This may be visualized as a curved surface of a strong plus cylinder lens. When placed on the upper jaw of the needle holder this convex surface falls onto the curve of the needle. Further, I feel that the lower jaw may be made concave to approximate the convex side of the needle. This holds the needle firmly without twisting or turning.

The jaw of the needle holder may be on a handle of the operator's choice. The needle holder supplied me by the Storz Instrument Company, of St. Louis, has the handle of a Kalt needle holder. The essential thing is to have the surface of the upper jaw convex to fit in the curve of the needle. The lower jaw may be made, according to Mr. Storz's opinion, so that "if the lower jaw, or convex curve, is made a little deeper than the concave jaw, it will permit the use of a variety of curved needles without hurt to the needle and that if the needle is held firmly on two points and not all across the curve, the needle holder will still have a good grip on the needle."

## A SUCTION DEVICE FOR USE IN THE TREATMENT OF STYES

JAMES P. GILL, M.D., SAN ANTONIO, TEXAS

The apparatus shown in the accompanying illustration has been of considerable service to me in evacuating the contents of small abscesses about the eyelids. Through the medium of a rubber bulb and an appropriate tip, it provides an inexpensive means of applying suction. The larger tip and the bulb in combination constitute a suction outfit sold in drugstores for the treatment of snake bite. With the large metal tip a considerable area of the lid can be treated at one time. The smaller



Suction device for the treatment of styes.

tip consists of an ordinary straight glass medicine dropper from which the bulb has been removed. The point of the medicine dropper fits snugly into the opening in the large rubber bulb; the flanged extremity can be applied to isolated points of suppuration after they have been incised, and the contents can readily be evacuated. The low cost of the instrument will recommend it to most ophthalmologists, and its use in treating infections about the eyelids will be apparent on trial.

# ANGIOID STREAKS

ROY O. SCHOLZ, M.D.

BALTIMORE

The clinical entity now known as angioid streaks was first described and illustrated by Doyne, in 1889. Unaware of this description Plange reported a second case in 1891, in the *Archiv für Augenheilkunde,* and when this article appeared in the ARCHIVES OF OPHTHALMOLOGY Knapp published a third case. In the latter article, "On the Formation of Dark Angioid Streaks as an Unusual Metamorphosis of Retinal Hemorrhage," the striations received their enduring name angioid, which is derived from a Greek root meaning vessel-like. In 1927 Holloway collected 58 cases of angioid streaks from the literature and presented the first composite picture of the disease.

Pseudoxanthoma elasticum of the skin, which was described by Balzer in 1884 and named by Darier in 1896, was first noted in connection with an unknown retinal condition in 1903 by Hallopeau and Laffitte. These authors suggested the possibility of a connection between the two conditions. This suggestion was confirmed by Grönblad in 1929, when he described 2 patients with angioid streaks of the retina in whom Strandberg demonstrated cutaneous lesions of pseudoxanthoma elasticum. The syndrome of angioid streaks and pseudoxanthoma elasticum was subsequently named that of Grönblad and Strandberg.

In 1929 Rowland presented a case of angioid streaks and osteitis deformans, or Paget's disease, before the New England Ophthalmological Society. In 1932 Terry collected 5 cases of angioid streaks associated with osteitis deformans from the literature and added 4 new cases, suggesting that this association constituted a new syndrome.

A total of 182 cases of angioid streaks have now been described in the literature. These 182 cases with the addition of 6 cases from the Wilmer Institute constitute the material for this review.

## REPORT OF CASES

Angioid streaks have been recognized in 6 patients examined in the Wilmer Institute during the past two years. In view of the fact that

From the Wilmer Ophthalmological Institute of Johns Hopkins University and Hospital.

complete case reports of this entity are still not numerous, these 6 cases are briefly described.

CASE 1.—R. K., a 44 year old Negro, came to the Wilmer Institute because of depreciation of vision over a six month period. Corrected vision was 20/70 in the right eye with a —1.00 D. sph. and 20/100 in the left eye with a —1.50 D sph. Ophthalmoscopically the right eye showed an area of atrophic choroiditis and a mass of glial tissue in the macular region. Wide, branching brown angioid streaks were seen radiating from a peripapillary ring of the same nature (fig. 1, *A* and *B*). The left eye showed a similar picture and in addition a hole in the macula (fig. 1, *C* and *D*). Examination of the skin showed a typical clinical and histologic picture of pseudoxanthoma elasticum (fig. 2). General examination revealed no other abnormalities except latent serologic syphilis which had been adequately treated. One sister was examined and found to have normal eyes. The condition in this case illustrates the broader type of angioid streaks.

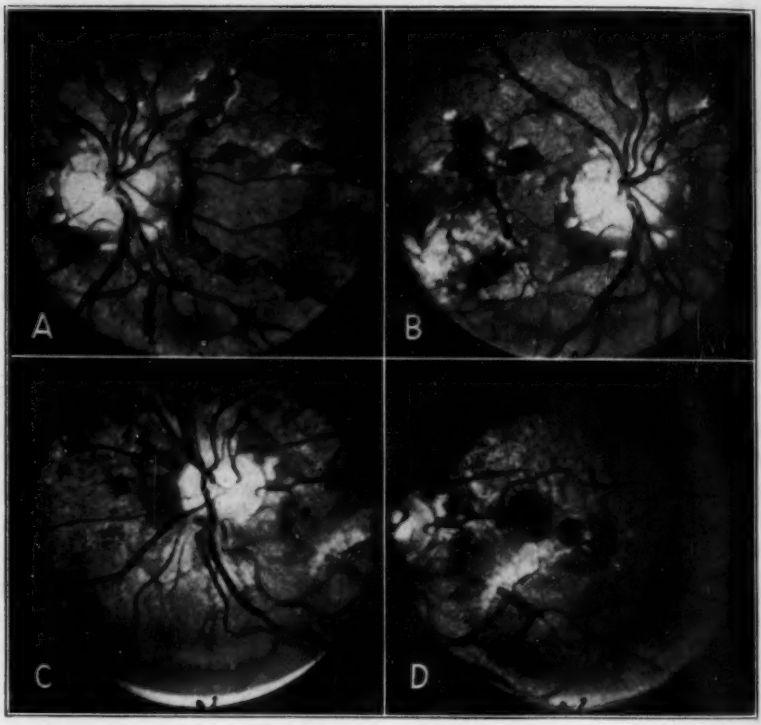



Fig. 1 (case 1).—Angioid streaks. *A* (right eye), the angioid streaks are of the broadest type seen. *B* (right eye), the atrophic choroiditis and glial tissue are seen in the macula. *C* (left eye), the streaks are finer. *D* (left eye), the hole in the macula is illustrated, in addition to the atrophic choroiditis.

CASE 2.—C. M., a 47 year old Negro, came to the Wilmer Institute because of conjunctivitis. His vision, uncorrected, was 20/20 in each eye. Ophthalmoscopic

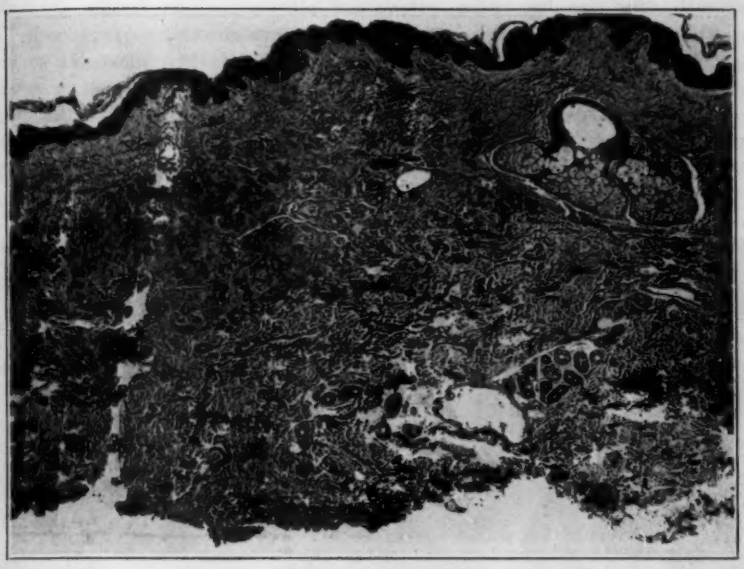


Fig. 2 (case 1).—Pseudoxanthoma elasticum. Biopsy specimen of skin stained with hematoxylin and eosin (× 25), showing characteristic changes. Note the fragmentation and basophilic staining of the elastic tissue.

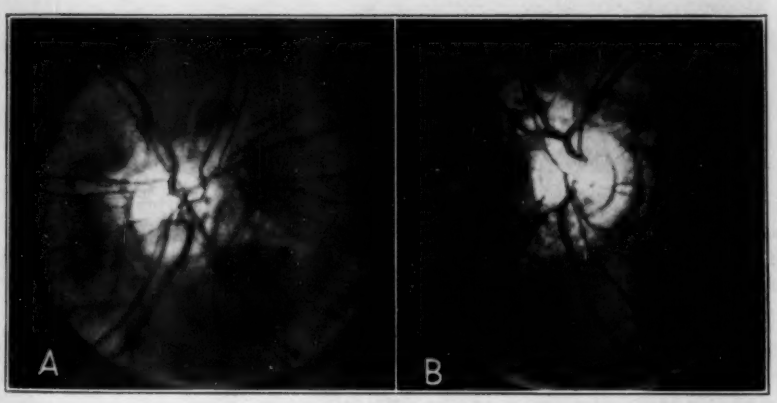



Fig. 3 (case 2).—Angioid streaks. *A*, right eye. *B*, left eye. The angioid streaks in this case are fine and do not extend far into the periphery. There is no macular involvement.

examination showed several narrow brown angioid streaks radiating a short distance from a peripapillary ring. There was a small amount of peripapillary choroiditis. The maculae, retinal vessels and periphery of the fundi were normal (fig. 3). No clinical evidence of pseudoxanthoma elasticum was found. The patient had previously been in the medical wards, where a diagnosis of acute rheumatic fever had been made. Roentgen studies of the long bones showed no osteitis deformans, but there were numerous areas of replacement of the normal bony structure, which were thought to be the result of lymphoblastoma or of a blood dyscrasia. The condition in this case illustrates an early uncomplicated type of angioid streaks.

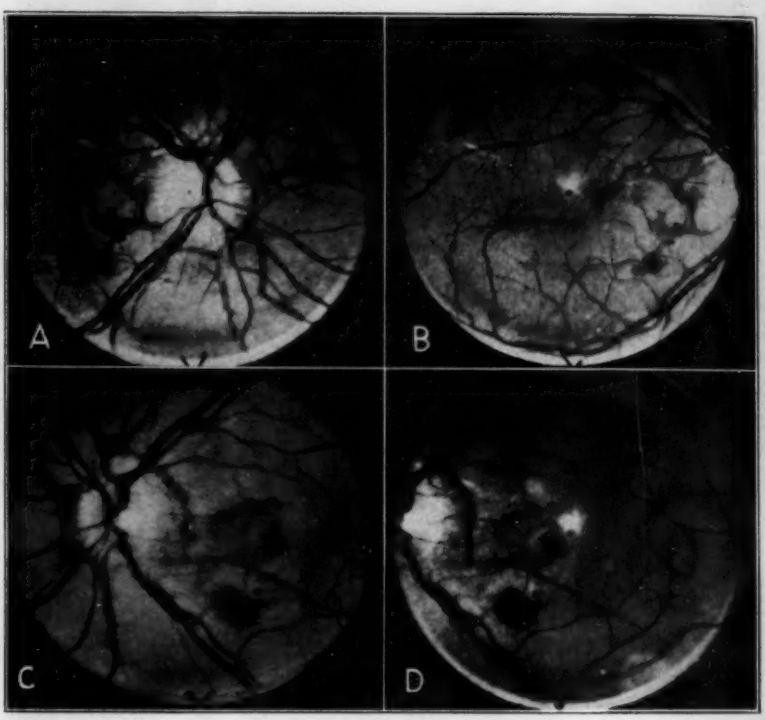



Fig. 4 (case 3).—Angioid streaks. *A* (right eye), the angioid streaks illustrate a clearcut peripapillary ring. *B* (right eye), hemorrhage in the macula. *C* (left eye), a flat hemorrhage in the retina. *D* (left eye), the plaque of glial tissue and flat hemorrhage in the macular region.

Case 3.—E. K. M., a 46 year old white man, entered the Wilmer Institute with the complaint of decrease in vision in the right eye during the preceding five months and a blurring of vision in the left eye for three weeks. The patient stated that Dr. Wilmer had noted streaks in his eyes twenty-six years before. Vision in the right eye with a —1.00 D. sph. — 2.50 D. cyl., axis 97, was 20/20 — 3; vision in the left eye with a — 1.00 D. sph. — 2.25 D. cyl., axis 83, was 20/50. Ophthalmoscopically dark brown angioid streaks were seen radiating from a peripapillary ring about each disk. There were flat hemorrhages in the macular

region of the right eye (fig. 4, *A* and *B*) and hemorrhages with a plaque of glial tissue in the region of the left eye (fig. 4, *C* and *D*). Visual fields showed a central scotoma in the left eye. No areas of pseudoxanthoma elasticum were found. A thorough medical examination revealed the absence of vascular pulsations in the lower extremities. Roentgen ray studies of the skull and long bones did not reveal any signs of osteitis deformans. Complete studies of the blood, including determinations of calcium, phosphorus and phosphatase activity, gave normal results. A positive reaction was elicited by 0.001 mg. of old tuberculin. The condition in this case illustrates the somewhat finer type of angioid streaks with early hemorrhages.

Case 4.—C. J., a 49 year old white woman, was seen in routine consultation in the surgical service, to which she had been admitted because of recurrent hematemesis. She had worn glasses and had satisfactory vision until five years before the examination, when she noted her vision had decreased in the left eye to about half. Vision in the right eye had remained unaffected. Vision in the

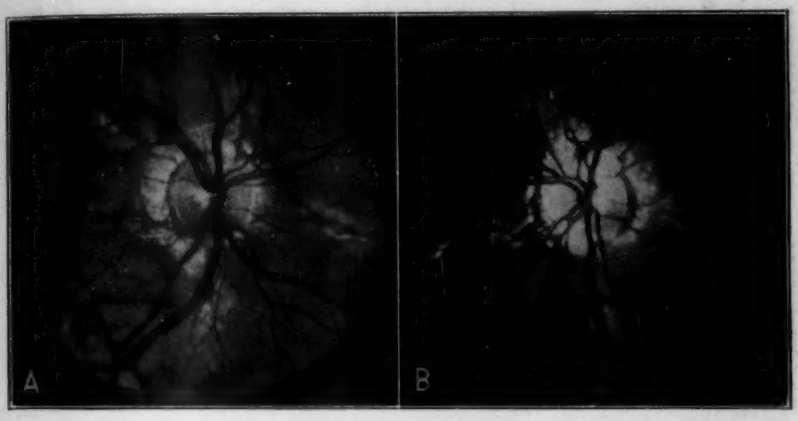



Fig. 5 (case 4).—Angioid streaks. *A*, peripapillary chorioretinal degeneration. *B*, the colloid deposits over the upper edge of the disk are seen.

right eye with a + 1.25 D. sph. was 20/20; vision in the left eye with a + 1.25 D. sph. was 20/20. The visual fields of the right eye showed 15 degrees temporal constriction to white; the visual fields of the left eye were roughly concentric, leaving 60 degrees temporally and 50 degrees nasally with 10 degrees below and 20 degrees above. Ophthalmoscopic examination of the right eye showed (fig. 5 *A*) that the media were clear and the disk was sharply outlined. Surrounding the disk was a rather extensive chorioretinal degeneration. Two dark gray streaks radiated outward from the disk, one coursing upward and the other nasally. Each gradually tapered off toward its termination. Between the disk and the macula there were a few very fine yellowish dots. In the periphery the retina had a pepper and salt appearance. The vessels were normal, and no hemorrhages were seen. In the left eye (fig. 5 *B*) the disk had several colloid deposits, one situated at the upper and the other at the lower pole. These protruded into the vitreous, and the vessels coursed over them. There were extensive chorioretinal degeneration around the disk and four or five dark grayish streaks radiating outward in the upper

part of the fundus. The periphery of the fundus was considerably more mottled than that of the right eye. The retinal vascular tree was normal. The patient had pseudoxanthoma elasticum of the skin and secondary syphilis. Roentgen ray examination of the skull and long bones showed negative results, as did chemical studies of the blood, including the determinations of serum phosphatase.

CASE 5.—R. H., a white man aged 21, was seen because of eyestrain and headaches of two weeks' duration. He had worn glasses since the age of 6 years. Vision in the right eye with a —0.75 D. sph. —1.62 D. cyl., axis 168, was 20/15; vision in the left eye with a —0.62 D. sph. —1.62 D. cyl., axis 160, was 20/15. On ophthalmoscopic examination a halo of fine brown branching lines was seen around each disk, from which similar lines branched and extended far into the periphery (fig. 6). The streaks were described as lying beneath the retinal vessels. The macular areas were normal. No evidence of osteitis deformans or of pseudoxanthoma elasticum could be found in this patient.

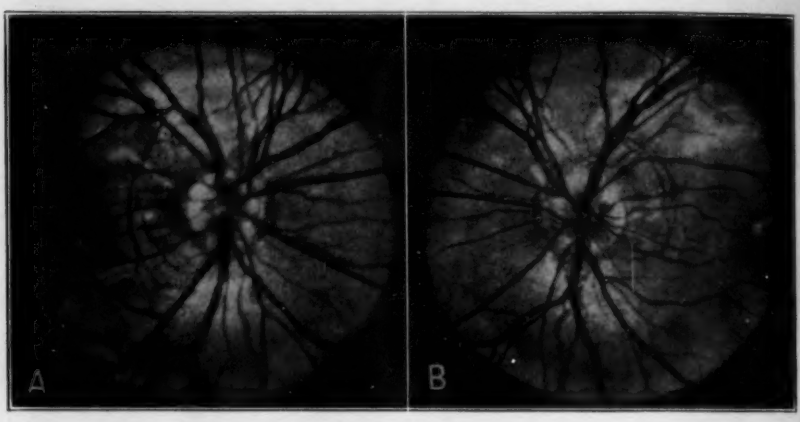



Fig. 6 (case 5).—Angioid streaks. *A*, right eye. *B*, left eye. Both eyes show the fine type of streaks, with no macular lesions.

CASE 6.—A. R., a 26 year old white man, came to the accident room because of a foreign body in the right cornea. Vision, corrected, was 20/20 in the right eye and 20/200 in the left. Ophthalmoscopic examination revealed extensive chorioretinal scars in each eye and macular involvement in the left eye. Numerous fine, branching black angioid streaks were seen in both fundi. The patient was uncooperative and could not be examined further.

## ANALYSIS OF THE LITERATURE

Reports of a total of 188 typical cases of angioid streaks are available for tabulation and analysis. In many instances the same patients were observed by different authors, but duplicate case reports were excluded as far as possible. An atypical lesion which has been called angioid streaks will be discussed in detail when the differential diagnosis

is considered. Cases of such atypical conditions are not included in the following analysis.

*Country.*—Cases have been reported from nearly all sections of the globe: Germany, 66; United States, 60; Great Britain, 17; the Scandinavian countries, 14; France, 9; Japan, 8, and the South American countries, 6.

*Race.*—Except for 6 Negroes and 6 Japanese all the patients reported on were of the white race.

*Sex.*—Of the 175 cases in which the sex was mentioned, in 58 per cent the patients were males. This preponderance of males is not statistically significant.

*Age.*—In the greatest number of cases the condition appeared between the second and fifth decades of life, with the peak in the fifth decade. The distribution according to decades is as follows: 1 case in the first, 9 in the second, 28 in the third, 35 in the fourth, 63 in the fifth, 25 in the sixth, 7 in the seventh and 3 in the eighth. The sharp decline of case incidence in the sixth decade and the few patients over 70 years of age reported indicate either that the life expectancy of patients with this condition is decidedly shortened or that the fundus picture changes in the aged.

*Onset of the Disease.*—Depreciation of vision over a period of from several months to a year or more was the most frequent complaint, having been recorded for 72 patients. A history of trauma, which has been cited as an important factor, was obtained from only 24 patients, over half of whom sustained their trauma more than two years before they were observed. Nine patients complained of metamorphopsia. Seventy-nine reports do not indicate the nature of the presenting complaint.

*Visual Acuity.*—The visual acuity was recorded for 140 patients. Of these, 37 per cent had a corrected vision of 20/20 in each eye; 29 per cent had a visual acuity of between 20/30 and 20/100, and 33 per cent had vision lower than 20/200. The refractive error was recorded for 85 patients. Of these, 37 per cent were myopic, 37 per cent were emmetropic and 26 per cent were hyperopic. The excess of myopia is statistically significant.

*Visual Fields.*—Visual field studies were reported for 80 patients, and the fields were always normal except in those patients in whom there were other causes for defects. In 40 cases central scotomas were reported, although the incidence was no doubt higher, considering the large number of macular lesions found.

*Color, Size and Distribution of the Streaks.*—The color of the streaks was noted in 103 patients. In 65 the streaks were described as brown

or reddish brown, in 27 as gray and in the remainder as red, black, white or gray-brown. Coppez and Danis described streaks of different colors in the same eye. The streaks were always described as brown in Negroes.

Angioid streaks always have a serrated border, which may be pigmented or white, a white border having been variously attributed to scarring or to a light reflex on the edge of a fissure. Angioid streaks vary in width from the most minute fissure to four or five times the width of large retinal veins.

Coppez and Danis, Fleischer and Zentmayer have all stated that the streaks become less distinct with age. Ascher reported the disappearance of angioid streaks of very typical appearance over a period of two years.

Angioid streaks always radiate from a peripapillary ring of the same nature. They are situated beneath the retinal vessels and above the choroidal vessels and show no constant relation to either. The streaks may radiate like spokes of a wheel or be connected with one another to form a mosaic. They are usually present in at least two quadrants of the fundus.

Although in many patients only one fundus was observed, because of opacities which prevented a view of the opposite fundus, cases of truly monocular involvement are rare. Grönblad reported a monocular case and Isayama another, in which he described "no angioid streaks but only a greenish-gray-white peripapillary choroidal atrophy which apparently could be considered a precursor of angioid streaks" in the opposite eye.

*Intraocular Conditions.*—The macula was found to be abnormal in one or both eyes of 140 patients. In 35 of these recent hemorrhages were observed, in 19 scarring, in 18 abnormal pigmentation and in the remaining 23 a hole in the macula or exudate or specific types of retinitis, such as disciform degeneration of Kuhnt [1] or retinitis circinata.[2] Retinal hemorrhage was described in 65 patients and choroiditis of one type or another in 70.

Angioid streaks in themselves have no effect on visual acuity. Since these streaks are often difficult to detect and can easily be overlooked in routine fundus examinations, it is not surprising that they are most often described in patients exhibiting other choroidal or retinal pathologic changes, which render a very careful ophthalmoscopic examination imperative.

*Pseudoxanthoma Elasticum and Osteitis Deformans.*—The relation of pseudoxanthoma elasticum to angioid streaks was first noted in 1929

1. Franceschetti and Roulet. Matsuzawa. Goedbloed.
2. Morgan. Neame.

(Grönblad), and that of osteitis deformans to angioid streaks, in 1934 (Terry). With the consideration of only those 139 case reports which have appeared since the association of pseudoxanthoma elasticum with the streaks was first pointed out as a basis for calculation, the incidence of associated cutaneous or skeletal changes is as follows:

Pseudoxanthoma elasticum was found in 59 per cent of the patients with angioid streaks, was said to be definitely absent in 13 per cent and was not mentioned in regard to 18 per cent. There are 5 case reports of senile elastosis of the skin accompanying angioid streaks.[3] Sandbacka-Holström stated in his analysis of 100 cases of pseudoxanthoma elasticum found in the literature that in 87 there were angioid streaks.

Osteitis deformans was detected in 9 per cent of the 139 cases of angioid streaks reported in the literature since 1929.[4] The osteitis deformans was questionable in 1 instance (Malbrán and Adrogué), and in that case the patient also had pseudoxanthoma elasticum.

Terry studied 22 patients with osteitis deformans and found angioid streaks in 3 of them. Berliner found angioid streaks only once in a study of 29 patients with osteitis deformans, and streaks were present in only 1 of 14 patients with this disease who were recently examined in the Wilmer Institute.

Thus, of 65 patients with osteitis deformans whose fundi have been carefully examined for angioid streaks, typical streaks were detected in only 8 per cent.

*Familial Occurrence.*—De Schweinitz, in 1897, described angioid streaks in 2 brothers. This report has been followed by seventeen others [5] in which 2 siblings were reported as having the disease. Biozzi reported a family in which angioid streaks were found in a mother and 2 children. In 4 instances [6] the parents were consanguineous. Hartung in 1932 published a complete review of the familial tendencies of both pseudoxanthoma elasticum and angioid streaks. The evidence to date indicates that both angioid streaks and pseudoxanthoma elasticum are hereditary syndromes transmitted as a recessive hereditary characteristic.

*Prognosis.*—Of all the cases in the literature only 46 were observed for over a year. Fleischer, in 1938, reporting on Oeller's patient, said that the patient's vision remained good for twenty-three years but after that, owing to macular involvement, it decreased to the ability to count

3. Clay. Biozzi. Reichling.

4. Terry. Malbrán and Adrogué. Lambert.

5. Lindner. Spicer. Lederer. Wildi. Batten. Biozzi. Clay. Krantz. Hartung. Sugg and Stetson. Blobner. Böck. Goedbloed. Law.

6. Hartung. Goedbloed. Matras. Franceschetti and Roulet.

fingers. Fewer streaks were visible on the second examination. Coppez and Danis in 1925 reported on a patient previously seen in 1908 (Coppez). This patient's vision likewise decreased from normal to 0.1 owing to macular involvement, and, as in the previous case, the streaks had become thinner, darker and less distinct. The streaks also decreased in Zentmayer's case while the macular lesions increased after eighteen years.

Of the patients who were followed for more than a year, 33 per cent showed an increase in the number of streaks; in 56 per cent the condition remained unchanged, and in 10 per cent the streaks decreased in number. The vision remained, on the whole, unchanged except as influenced by macular pathologic changes.

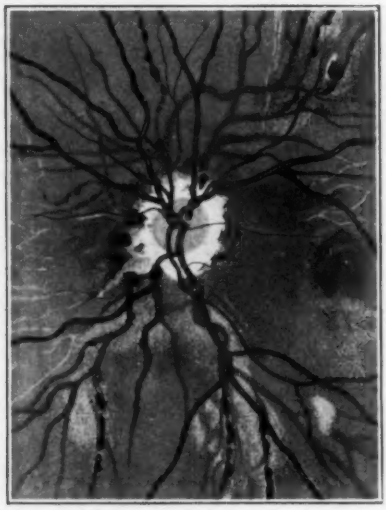


Fig. 7.—"Rosary" or "pearl bead" stripes (Siegrist's case). The clumped pigment is clearly seen over the choroidal vessels. (From Siegrist, A.: Internat. Ophth. Cong., Utrecht, 1899.)

## DIFFERENTIAL DIAGNOSIS

Although there are numerous fundus conditions which may present streaks, there are few which give rise to diagnostic confusion when the distinctive picture of angioid streaks is considered.

*"Rosary" or "Pearl Chain" Streaks.*—Perhaps the condition most frequently confused in the literature is that of "rosary" or "pearl chain" streaks. These are black granular pigment stripes which are not homogeneous, run radially along the choroidal vessels and are usually present in the vicinity of the optic disk. The granular pigment deposit is seen over the entire length of the streaks (fig. 7). Siegrist, in 1899,

first described these streaks, with a histologic study in 1 of his 2 cases. Since then 19 case reports [7] of these streaks have been published, several instances being erroneously presented as cases of angioid streaks.[8] In all reported cases the patients were elderly, had hypertensive cardiovascular disease and were predominantly males. Siegrist described the primary pathologic change as pigment proliferation in the choroid over partially but not completely sclerosed choroidal vessels. Fuchs (1930), on the other hand, found obliterated choroidal arteries with proliferated pigment epithelium over them. Bayer reviewed Magitot's cases and also described an abnormal amount of pigment.

*Pigment Streaks Following Choroidal Detachment.*—A second type of streak occurs after choroidal detachment, particularly following the Elliot trephine operation. This type was first reported by Schur in 1913, with a description of 3 cases. Plocher stated that this type occurred more frequently than reports indicated. Fuchs (1917) attributed streaks of this kind to folds in the pigment epithelium formed during the detachment and remaining after the choroid has replaced itself. Such stripes occur in the periphery of the fundus and are black, granular, numerous and not infrequently branched. They are usually meridional in direction. Verhoeff (1931), on postmortem examination of an eye enucleated after a combined cataract extraction with loss of vitreous, found gross pigment stripes in the periphery of the fundus. Microscopically he found them to be ridgelike thickenings of the pigment epithelium between Bruch's membrane and the retina proper. From a further study of cases he demonstrated that the detached choroid formed folds in the adjacent retina. He suggested that pigment cells accumulate in these folds and remain after the choroid has settled back.

*Perivascular Choroidal Pigment Atrophy.*—In the literature are described several cases of streaks which are formed by a zone of depigmentation around a choroidal artery.[9] These cases have been erroneously reported as instances of angioid streaks. An illustration of this type of lesion is shown in figure 8, taken from Wilmer's atlas. A similar condition is shown in the illustration of Böck's second case. Two additional patients with this type of streaks are being followed in this clinic and will be presented in a separate communication. Patients showing this lesion range from 9 to 50 years of age. None of those reported had hypertension. Both sexes are represented.

*Choroidal Arteriosclerosis.*—This condition should not be mistaken for angioid streaks. True angioid streaks are not related to the choroidal vessels in their distribution.

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7. Magitot. Lindner. E. Fuchs. Holm. Koppl. Jablonski. Zeeman. Vos.
8. Magitot (1911). Holm (1924).
9. Böck and Wilmer.

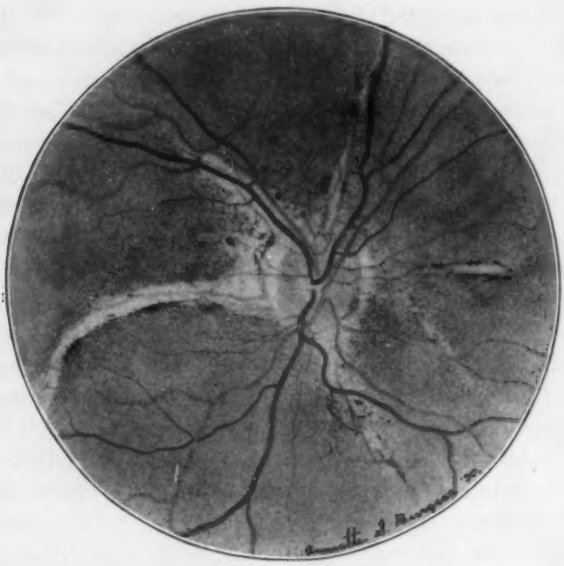

Fig. 8.—Perivascular choroidal pigment atrophy (Wilmer's case). A depigmented area is seen around the choroidal vessels (from Wilmer, W. H.: Atlas Fundus Oculi, New York, The Macmillan Company, 1934 [fig. 92]).

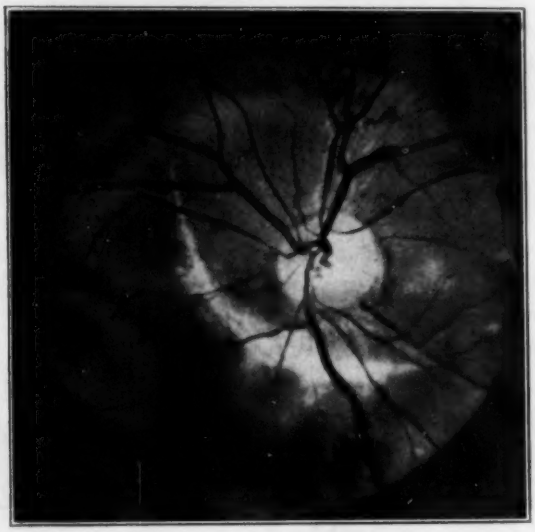

Fig. 9.—Rupture of the choroid.

*Rupture of the Choroid.*—Occasionally rupture of the choroid at the posterior pole will give a picture not unlike a single angioid streak, but the location, the absence of a peripapillary ring and the monocular nature of the tear will make the diagnosis evident (fig. 9).

## PATHOLOGY

Speculations as to the histologic basis of angioid streaks have been numerous, but pathologic studies have been few and, until recently, unsatisfactory. Doyne expressed the opinion that the ocular condition was due to a tearing of the pigment epithelium of the retina. Plange, de Schweinitz, Holden and Pagenstecher stated the belief that these streaks formed after repeated retinal hemorrhages. Walser suggested that the stripes were due to folding of the retina. Pretori suggested that the condition was a congenitally abnormal development, while Poos stated that it was due to a constitutional congenital predisposition. Zentmayer expressed the opinion that the streaks were pigmented vessels of inflammatory or congenital origin. Still seeking to explain them as blood vessels, Collins stated that the streaks were in reality branches of the posterior ciliary arteries, the pigmented appearance being due to the disposition of insoluble blood pigment in the perivascular spaces. Still another vascular theory was presented by Clay, who suggested that the picture resulted from a thrombosis of short posterior ciliary veins which pass through the sclera in an anomalous manner. The last-mentioned theories found great favor in the 1920's and 1930's. All of these theories rested only on clinical observations. Lister in 1903 reported 2 cases in which pigment stripes were observed in the fundus after enucleation. He stated that this condition was of a totally different nature from angioid streaks but that it illustrated the mechanism by which a system of new blood vessels in the deeper layers of the retina present the appearance of angioid streaks. In 1909 Alt suggested that the appearance of the streaks may be due to folds of pigment epithelium slightly raised by a small amount of exudate.

Verhoeff (1928) described angioid streaks in an enucleated eye in which a corneal opacity had prevented ophthalmoscopic study of the fundus. In this case there was cicatricial contraction of the fibrous tissue, which had replaced the deeper layers of the choroid and which had resulted in folds in the choroid. There were extensive obliteration of the vessels, attributed to a possible congenital disturbance or defect in innervation of the choroidal vessels, and a few subchoroidal hemorrhagic extravasations. The other eye, although it was observed years later (Terry), never showed the picture of angioid streaks. It is to be recalled that only 2 cases of truly monocular angioid streaks have been reported.

Benedict, in a report of a case in which an eye was enucleated without ophthalmoscopic examination but in which the opposite eye showed

angioid streaks, stated: "Microscopic examination . . . failed to show any pathologic changes that could be identified as angioid streaks."

Law recently recorded a case of ruptured corneal ulcer in which angioid streaks had been observed ante mortem and were studied microscopically post mortem. In the position of the angioid streaks there were a well marked fold of the retina and a localized detachment between the pigment layer and that of the rods and cones. In this space there was an accumulation of extracellular pigment and pigment debris. These folds were not studied in serial section, and their relation to the angioid streaks was not definitely established.

Kofler in 1917 suggested that the appearance of the streaks might be due to fissures in the membrane of Bruch. This theory has now been confirmed in 2 separate case reports, by Hagedoorn and by Böck. In these 2 cases the diagnosis was established by antemortem examination, and a detailed postmortem study was made. The picture, as described in each instance, was one of a degeneration of the elastic fibers of Bruch's membrane. There was a heavy basophilic staining of this membrane, and in places there was a deposit of colloid beneath it. The membrane exhibited numerous ruptures, which when reconstructed were shown to correspond in distribution to the angioid streaks. The retina was normal. Both patients had concurrent pseudoxanthoma elasticum and in addition showed degeneration of the elastic tissue of the smaller arteries and of the aorta.

Gifford and Cushman have recently discussed the retinopathies due to changes in the lamina vitrea and have reported a clinical case of angioid streaks of the retina associated with hyaline deposits in the lamina vitrea. These authors accepted the pathologic explanation of the streaks as given by Hagedoorn.

Recently Verhoeff (1939) has objected to this explanation of angioid streaks, stating that a previous study of Verhoeff and Sisson, in 1926, had shown that basophilic staining of the membrane is "without pathological significance and is simply a senile change which usually does not impair the function of the eye." In this study he had found 70 examples of basophilia of Bruch's membrane among 600 eyes examined.

Of over 200 eyes obtained at autopsy in the department of pathology of the Johns Hopkins Hospital, approximately 10 per cent showed basophilic staining of Bruch's membrane. In 2 cases the basophilia was marked and there was fragmentation of the membrane (fig. 10) similar to that described by Hagedoorn and Böck. One of these instances was a case of osteitis deformans, of which there were only 3 cases in this series. The other case of basophilia and fragmentation of Bruch's membrane was that of a patient with an adenocarcinoma

of the prostate obstructing the urethra; he also had a positive Wassermann reaction. Unfortunately, no examination of the fundus was recorded in these cases.

In pathologic sections of skin of patients with pseudoxanthoma elasticum the elastic fibers in the middle and deep parts of the corium are swollen, split up and fragmented. This degeneration of the elastic fibers is also found in other parts of the body in persons afflicted with this disease. Although, as was previously stated (Ohno), the fibers were calcified, it remained for Finnerud and Nomland in a recent study to demonstrate by staining methods, by incineration, by quantitative chemical analysis and by microchemical means that the degener-

Fig. 10.—Osteitis deformans. Section of choroid (hematoxylin and eosin stain, ×450), showing the marked basophilic staining and fragmentation of Bruch's membrane.

ated elastic tissue is rightly infiltrated with calcium occurring in the form of calcium phosphate.

In osteitis deformans the process of absorption and ossification of the diseased bones proceed together. There are a replacement of the original bone by connective tissue and a substitution of cancellous bone. The bones which are at first soft later become hard. A high serum phosphatase activity is an early diagnostic aid. Studies of metabolism of patients with this disease (Da Costa and others) have given inconstant results but in general show that there is retention of calcium, magnesium and phosphorus with a loss of sulfur. Analysis of the

bones show that in spite of their softness they are especially rich in calcium.

The factor causing the deposit of calcium in the skin of patients with pseudoxanthoma elasticum and in the bones of patients with osteitis deformans is not known, nor is the nature of the basophilic substance deposited in Bruch's membrane. The suspicion that basophilic staining of the membrane is associated with calcification is perhaps justifiable on histologic grounds but has not been definitely proved. No disorder of calcium metabolism was found on chemical study in cases 3 and 4 presented in this paper.

## BIBLIOGRAPHY


Alt, A.: Am. J. Ophth. **26**:171, 1909.

Aosina, S.: Hihu-to-Hitunyo **7**:245, 1939; abstracted, Zentralbl. f. d. ges. Ophth. **44**:240, 1940.

Arai, S.: Hihu-to-Hitunyo **3**:146, 1935; abstracted, Zentralbl. f. d. ges. Ophth. **34**: 457, 1935.

Ascher, K.: Klin. Monatsbl. f. Augenh. **88**:685, 1932.

Bachsingan-Frenkel: Russk. arch. oftal. **3**:498, 1928; abstracted, Zentralbl. f. d. ges. Ophth. **19**:237, 1928.

Balzer, F.: Arch. de physiol. norm. et path. **4**:65, 1884.

Basombrio, G.: Rev. argent. dermato-sif. **20**:579, 1936.

Batten, R.: Brit. J. Ophth. **15**:279, 1931.

Bayer, H.: Klin. Monatsbl. f. Augenh. **51**:766, 1913; abstracted, Ophth. Rev. **32**:310, 1913; Klin. Monatsbl. f. Augenh. **52**:677, 1914.

Benedict, W. L.: The Pathology of Angioid Streaks in the Fundus Oculi, J. A. M. A. **109**:473 (Aug. 14) 1936.

——and Montgomery, H.: Am. J. Ophth. **18**:205, 1935.

Berliner, M. L., in discussion on Newman, D. A.: Angioid Streaks of the Retina with Pseudoxanthoma Elasticum, Arch. Ophth. **10**:709 (Nov.) 1933.

Biozzi, G.: Boll. d'ocul. **12**:1303, 1933; abstracted, Zentralbl. f. d. ges. Ophth. **31**:127, 1934.

Blobner, F.: Klin. Monatsbl. f. Augenh. **95**:12, 1935.

Böck, J.: Ztschr. f. Augenh. **95**:1, 1938.

Bonnet, P.: Arch. d'opht. **50**:721, 1933; **52**:225, 1935.

Brewerton, E.: Am. J. Ophth. **2**:340, 1919.

Brill, E. M.: Ztschr. f. Augenh. **77**:319, 1932.

Calhoun, F. P.: Tr. Am. Ophth. Soc. **25**:209, 1927.

Clay, G.: Angioid Streaks of the Retina and Pseudoxanthoma Elasticum, Arch. Ophth. **8**:334 (Sept.) 1932.

Collins, E. T.: Tr. Ophth. Soc. U. Kingdom **43**:273, 1923.

Coppez, H.: Arch. d'opht. **28**:453, 1908.

——and Danis, M.: ibid. **42**:649, 1925.

Corrado, M.: Ann. di ottal. e clin. ocul. **66**:801, 1938.

DaCosta, J. C., and others: Publ. Jefferson M. Coll. & Hosp. **6**:1, 1915.

Darier, J.: Monatsh. f. prakt. Dermat. **20**:609, 1896.

Denti, A. V.: Ann. di ottal. e clin. ocul. **65**:93, 1937.

Dohi, T.: Acta Soc. ophth. jap. **42**:2005, 1938; abstracted, Zentralbl. f. d. ges. Ophth. **42**:637, 1938.

Doyne, R. W.: Tr. Ophth. Soc. U. Kingdom **9**:128, 1889.

Dunn, J.: Arch. Ophth. **26**:388, 1897.
Dykman, A. B.: Angioid Streaks of the Retina, Arch. Ophth. **11**:283 (Feb.) 1934.
Ehlers, H.: Ber. ü. d. Versamml. d. ophth. Gesellsch., 1934; abstracted, Zentralbl. f. d. ges. Ophth. **33**:538, 1935.
Elwyn, H.: Am. J. Ophth. **23**:1163, 1940.
Finnerud, C., and Nomland, R.: Pseudoxanthoma Elasticum, Arch. Dermat. & Syph. **35**:653 (April) 1937.
Fleischer: Klin. Monatsbl. f. Augenh. **53**:430, 1914; **100**:771, 1938.
Franceschetti, A., and Roulet, E. L.: Arch. d'opht. **53**:401, 1936.
François, J.: Bull. Soc. belge d'opht. **78**:99, 1939.
Frydman, R.: Ann. d'ocul. **175**:154, 1938.
Fuchs, A.: Klin. Monatsbl. f. Augenh. **84**:39, 1930.
Fuchs, E.: Arch. f. Ophth. **94**:107, 1917.
Gifford, S. R., and Cushman, B.: Certain Retinopathies Due to Changes in the Lamina Vitrea, Arch. Ophth. **23**:60 (Jan.) 1940.
Goar, E. L.: Am. J. Ophth. **21**:907, 1938.
Goedbloed, J.: Syndrome of Groenblad and Strandberg, Arch. Ophth. **19**:1 (Jan.) 1938.
Griscom, M.: Tr. Coll. Physicians Philadelphia **49**:215, 1927.
Grönblad, E.: Acta ophth. **7**:329, 1929; (supp. 1) **10**:1, 1932.
Guist, G.: Klin. Monatsbl. f. Augenh. **64**:565, 1920.
Haack, F., and Minder, E.: Arch. f. Dermat. u. Syph. **167**:717, 1933.
Hagedoorn, A.: Angioid Streaks, Arch. Ophth. **21**:746 (May); 935 (June) 1939.
Hallopeau and Laffitte: Ann. de dermat. et syph. **4**:595, 1903.
Hartung, H.: Klin. Monatsbl. f. Augenh. **88**:43, 1932.
Hay, P.: Tr. Ophth. Soc. U. Kingdom **48**:443, 1928.
Heed, C. R.: Tr. Coll. Physicians Philadelphia **38**:344, 1916; abstracted, Am. J. Ophth. **1**:583, 1918.
Heggs, G. M., and Williamson-Noble, A.: Proc. Roy. Soc. Med. **29**:294, 1936.
Herrmann: Klin. Monatsbl. f. Augenh. **79**:656, 1927.
Higaski, T.: Jahresb. d. Kurashiki-Zentralhosp. **4**:11, 1929; abstracted, Zentralbl. f. d. ges. Ophth. **23**:792, 1930.
Hilding, A.: Am. J. Ophth. **18**:369, 1935.
Holden, W.: Arch. Ophth. **24**:147, 1895.
Holloway, T. B.: Tr. Am. Ophth. Soc. **25**:173, 1927.
Holm, E.: Acta ophth. **2**:152, 1924; **5**:188, 1927; Ber. ü. d. Versamml. d. deutsch. ophth. Gesellsch. **53**:20, 1937; abstracted, Zentralbl. f. d. ges. Ophth. **42**:112, 1938.
Hubert, K.: Norsk mag. f. lægevidensk. **99**:201, 1938; abstracted, Zentralbl. f. d. ges. Ophth. **41**:330, 1938.
Hughes, W. L.: Angioid Streaks of the Fundus Oculi, Arch. Ophth. **1**:551 (May) 1929.
Isayama, H.: Acta Soc. ophth. jap. **44**:134, 1940.
Ishikawa: Acta Soc. ophth. jap. **36**:1197, 1932; abstracted, Zentralbl. f. d. ges. Ophth. **28**:380, 1933.
Jablonski: Arch. f. Augenh. **103**:665, 1930.
Jacoby, M. W.: Pseudoxanthoma Elasticum and Angioid Streaks, Arch. Ophth. **11**:828 (May) 1934.
Jennings: Ann. Ophth. **13**:699, 1904.
Klein, B.: Am. J. Ophth. **17**:353, 1934.
Knapp, H.: Arch. Ophth. **21**:289, 1892.

Köhne, W.: Arch. f. Ophth. **95**:97, 1918.
Kofler, A.: Arch. f. Augenh. **82**:134, 1917.
Komoto, S.: Chuo-Ganka-Iho **27**:7, 1935; abstracted, Zentralbl. f. d. ges. Ophth. **34**:543, 1935.
Koppl, A.: Ztschr. f. Augenh. **66**:131, 1927.
Krantz, W.: Dermat. Wchnschr. **94**:233, 1932; abstracted, Zentralbl. f. d. ges. Ophth. **27**:92, 1933.
Lambert, R. K.: Paget's Disease with Angioid Streaks of the Retina, Arch. Ophth. **22**:107 (July) 1939.
Law, F. W.: Tr. Ophth. Soc. U. Kingdom **58**:191, 1938.
Lederer, R.: Klin. Monatsbl. f. Augenh. **71**:776, 1923.
Lewis, G. M., and Clayton, M. B.: Pseudoxanthoma Elasticum and Angioid Streaks, Arch. Dermat. & Syph. **28**:546 (Oct.) 1933.
Lindner, K.: Arch. f. Ophth. **88**:230, 1914.
Lister, W. T.: Ophth. Rev. **22**:151, 1903.
Lohmann, W.: Arch. f. Augenh. **90**:203, 1921.
Ludy, J. B.: Pseudoxanthoma Elasticum, Arch. Dermat. & Syph. **38**:150 (July) 1938.
Magitot, A.: Ann. d'ocul. **114**:12, 1911.
Malbrán, J., and Adrogué, E.: Cong. argent. de oftal. (1936) **2**:68, 1938; abstracted, Zentralbl. f. d. ges. Ophth. **41**:443, 1938.
Marchesani, O., and Wirtz, F.: Arch. f. Augenh. **104**:522, 1931.
di Marzio, Q.: Saggi di oftal., 1924, p. 79; abstracted, Am. J. Ophth. **9**:861, 1926.
Matras, A.: Wien. klin. Wchnschr. **48**:198, 1935.
Matsuzawa, S.: Chuo-Ganka-Iho **28**:40, 1936; abstracted, Zentralbl. f. d. ges. Ophth. **38**:189, 1937.
Mayeda: Acta Soc. ophth. jap. **37**:525, 1933; abstracted, Zentralbl. f. d. ges. Ophth. **29**:669, 1933.
Meesmann, A.: Ztschr. f. Augenh. **73**:294, 1931.
Morgan, O. G.: Proc. Roy. Soc. Med. (Sect. Ophth.) **20**:881, 1927; abstracted, Arch. Ophth. **56**:305, 1927.
Muirhead: Tr. Ophth. Soc. U. Kingdom **48**:446, 1928.
Murata, M.: Jap. J. Dermat. & Urol. **33**:485, 1933; abstracted, Zentralbl. f. d. ges. Ophth. **29**:669, 1933.
Neame, H., cited by Batten.
Nomland, R., and Klien, B.: Pseudoxanthoma Elasticum of the Skin, Arch. Dermat. & Syph. **27**:849 (May) 1933.
Oeller, J. N.: Atlas seltener ophthalmoskopischer Befunde, zugleich Erganzungstafeln zu dem Atlas der Ophthalmoskopie, text translated into English by T. Snowball, Wiesbaden, J. F. Bergmann, 1903.
Ohno, T.: Arch. f. Dermat. u. Syph. **149**:420, 1935.
Onęto, J. A., and Gallino, J. A.: Cong. argent. de oftal. (1936) **2**:59, 1938; abstracted, Zentralbl. f. d. ges. Ophth. **42**:443, 1938.
Pagenstecher, H. E.: Arch. f. Ophth. **67**:298, 1908.
Plange, O.: Arch. f. Augenh. **23**:78, 1891; Arch. Ophth. **21**:282, 1892.
Plocher: Klin. Monatsbl. f. Augenh. **59**:610, 1917.
Poos, F.: Klin. Monatsbl. f. Augenh. **87**:734, 1931.
Porter, G. L., and Montgomery, H.: Proc. Staff Meet., Mayo Clin. **9**:109, 1934.
Pretori, H.: Beitr. z. Augenh. **24**:101, 1898.
Radnod, M.: Orvosi hetil. **84**:104, 1940; abstracted, Am. J. Ophth. **23**:1065, 1940.
Reichling, W.: Deutsche med. Wchnschr. **61**:1394, 1935.

Rowland, W. D.: Am. J. Ophth. **16**:61, 1933.
Sandbacka-Holmström: Förh. nord. dermat. För., 1939, p. 648; abstracted, Zentralbl. f. d. ges. Ophth. **44**:701, 1940.
Schrader: Ztschr. f. Augenh. **16**:81, 1906.
Schur, M.: Klin. Monatsbl. f. Augenh. **51**:372, 1913.
de Schweinitz, G. E.: Ophth. Rec. **6**:325, 1897; Tr. Am. Ophth. Soc. **8** (pt. 3):650, 1896.
Siegrist, A.: Internat. Ophth. Cong., Utrecht, 1899, p. 131.
Spicer, W. T. H.: Proc. Roy. Soc. Med. (Sect. Ophth.) **8**:33, 1914; Am. J. Ophth. **2**:340, 1919.
Stephenson, S.: Tr. Ophth. Soc. U. Kingdom **12**:140, 1892.
Sugg, E., and Stetson, D.: Pseudoxanthoma Elasticum Associated with Angioid Streaks of the Retina and Diabetes Mellitus, J. A. M. A. **102**:1369 (April 28) 1934.
Terry, T. L.: Tr. Am. Ophth. Soc. **32**:555, 1934.
Urrets, Z. A.: Arch. de oftal. de Buenos Aires **10**:233, 1935; abstracted, Zentralbl. f. d. ges. Ophth. **34**:709, 1935.
Vail, D., in discussion on Verhoeff (1928).
Venkei, T.: Dermat. Wchnschr. **107**:1396, 1938.
Verhoeff, F. H.: The Nature and Pathogenesis of Angioid Streaks in the Ocular Fundus, Tr. Sect. Ophth., A. M. A., 1928, p. 243.
Nature and Origin of Pigmented Streaks Caused by Separation of the Choroid, J. A. M. A. **97**:1873 (Dec. 19) 1931.
Angioid Streaks, Arch. Ophth. **22**:313 (Aug.) 1939.
——and Sisson, R. J.: ibid. **55**:129, 1926.
Vos, T.: Klin. Monatsbl. f. Augenh. **91**:408, 1933.
Walser, B.: Arch. Ophth. **25**:365, 1896.
Wassenarr, T.: Am. J. Ophth. **16**:759, 1933.
Wewe, H. J.: Klin. Monatsbl. f. Augenh. **92**:538, 1934.
Wildi, G.: Klin. Monatsbl. f. Augenh. **76**:177, 1926.
Wilmer, W. H.: Atlas Fundus Oculi, New York, The Macmillan Company, 1934, fig. 92.
Zeeman, W. P. C.: Nederl. tijdschr. v. geneesk. **76**:2047, 1932; cited by Burian, H.: Ztschr. f. Augenh. **84**:293, 1934; Klin. Monatsbl. f. Augenh. **90**:723, 1933.
Zentmayer, W.: Tr. Am. Ophth. Soc. **12**:267, 1909; Tr. Coll. Physicians Philadelphia **49**:216, 1927.
Ziporkes, J.: Angioid Streaks and Pseudoxanthoma Elasticum, Arch. Ophth. **24**: 473 (Sept.) 1940.

# News and Notes

## SOCIETY NEWS

**Canadian Ophthalmological Society.**—The fourth annual meeting of the Canadian Ophthalmological Society, held at the Chateau Frontenac, Quebec, on September 18 and 19, was very successful. Representatives from the air force and the naval services attended. Dr. Frederick Tooke, of Montreal, was elected president for the ensuing year; Dr. Colin Campbell, vice president, and Dr. Alexander E. MacDonald, secretary. The following physicians were elected to serve as members of the council: Dr. MacMillan, Montreal; Dr. Folger, Kingston, Ontario; Dr. Mathers, Halifax, Nova Scotia, and Dr. Septimus Thompson, London, Ontario.

## UNIVERSITY NEWS

**Graduate Course in Ophthalmology and Otolaryngology.**—The sixteenth annual spring graduate course in ophthalmology and otolaryngology will be given at the Gill Memorial Eye, Ear and Throat Hospital, Roanoke, Va., April 6 to 11, 1942. Among the guest speakers will be Drs. George E. Shambaugh Jr., Chicago; George M. Coates, Philadelphia; Norton Canfield, New Haven, Conn.; W. E. Grove, Milwaukee; Edwin N. Broyles, Baltimore; Warren Davis, Philadelphia; John R. Richardson, Boston; B. Y. Alvin, St. Louis; Harvey E. Thorpe, Pittsburgh; Wendell L. Hughes, New York; Earl L. Burky, Baltimore; Edmund B. Spaeth, Philadelphia, and E. B. Dunphy, Boston.

## GENERAL NEWS

**Course in Practical Gonioscopy.**—The Eye and Ear Research Fund, Inc., announces a two day course in practical gonioscopy which will be given at the Illinois Eye and Ear Infirmary, beginning Friday, October 24, at 2 p. m. and finishing Sunday, October 26, at noon. Applications and requests for particulars should be addressed to the Dean of Instruction, 904 West Adams Street, Chicago.

# Abstracts from Current Literature

EDITED BY DR. WILLIAM ZENTMAYER

## Conjunctiva

ESSENTIAL SHRINKAGE OF CONJUNCTIVA OR CONJUNCTIVAL PEMPHIGUS? REPORT OF CASES. F. W. MEYER, Klin. Monatsbl. f. Augenh. **101**: 708 (Nov.) 1938.

Meyer reports on 2 cases of essential shrinkage of the conjunctiva and the result of his examination of a specimen of this disease from Axenfeld's collection. He describes pemphigus of the mucous linings and the skin and refers to its relation to essential shrinkage of the conjunctiva, a term which he challenges because it refers only to the symptom of shrinkage, without alluding to the nature of the disease. Citing a related case published by Custodis he compares the symptoms in it with his own observations. He does not agree with Custodis in attributing the origin of the disease to an ultravisible virus, to endocrine and nervous disturbances or to intestinal toxic products.

Meyer's first patient, a man aged 38, had been under observation for ten years, since 1928. No pemphigus of the skin or other cutaneous lesions were noted. Intervals of ocular ease were followed by periods of ocular irritation. The palpebral fissures were narrowed, the canthus was obliterated by scar tissue, cicatricial strands and shrinkage were present in the conjunctivas and there were dark red foci denuded of epithelium. A few large and numerous dot-shaped erosions were present in the corneas. The corneas, except in the center, were covered by a parchment-like film, in which some of the conjunctival strands terminated. Vision was normal. Diplobacilli were observed in the conjunctival discharge. In 1928 and 1929 four plastic operations were done on the lids for trichiasis and progressive shrinkage. Formation of a bleb was noted only once. Treatment proved to be of no avail. Meyer made the diagnosis of foliaceous pemphigus. The cause could not be determined, but allergy was considered because of the presence of numerous eosinophilic cells.

The second patient, an obese man aged 82, was treated for simple conjunctivitis in 1936, two years prior to observation by Meyer. Shortly afterward there developed between the bulbar and the palpebral conjunctivas fine strands which suggested pemphigus. Congestion and the formation of blebs in the larynx also suggested pemphigus, and there was foliaceous pemphigus of the skin accompanied by large blebs. The cutaneous lesions, except one focus on the cheek, disappeared after treatment with ultraviolet radiation from a quartz lamp and with roentgen rays. Epiphora increased and shrinkage of the conjunctiva progressed, interfering with the ocular motion, which was finally eliminated. Clouding of the cornea advanced gradually, producing xerosis and ulceration. The temperature remained normal. The patient died from a fall downstairs. A detailed histologic description of both eyeballs, illustrated

by photomicrographs, is given. The lymph spaces in the conjunctiva were enlarged, and the upper layers were flattened and broadened. Such structural changes are observed in association with foliaceous pemphigus.

Meyer concludes that essential shrinkage of the conjunctiva and pemphigus are probably identical. The histologic changes in pemphigus foliaceus and in pemphigus of the conjunctiva are similar in many respects, but the courses differ because of local peculiarities. Differentiation appears to be as difficult between these two types of pemphigus as between pemphigus vulgaris and pemphigus foliaceus. The frequent simultaneous occurrence of the eruptions on the conjunctiva and on the skin suggests their identity, as the periodic alternation in severity of conjunctival pemphigus and the periodic reappearance of pemphigus of the skin are comparable. The pemphigus of the conjunctiva is a chronic inflammation which by formation of granulations terminates in shrinkage. The blebs are transient. Exfoliation is common to the lesions of the skin and those of the conjunctiva. The cause of the disease is unknown. Allergic influences have to be considered: Eosinophilic cells were found in the conjunctival discharge in both cases and in the histologic specimen in one. Such cells have been observed also in the content of the blebs of cutaneous pemphigus. No evidence of intestinal or hormonal disorders was found. Treatment failed to cure the conjunctival disease and to prevent recurrences, which may take place after several years. The prognosis is unfavorable.

K. L. STOLL.

## Cornea and Sclera

KERATOMALACIA AND CYSTIC FIBROSIS OF THE PANCREAS. R. C. GAMBLE, Am. J. Ophth. **23:** 539 (May) 1940.

Gamble gives a brief and interesting review of vitamin A deficiency and its symptomatology and pathology. He reports the case of a 3 month old boy who had keratomalacia in one eye. This improved apparently as the result of local use of percomorph liver oil. The response to general treatment was unsatisfactory, and the baby died. Autopsy revealed marked fibrosis of the entire pancreas. This evidently prevented assimilation of vitamin A, thus causing the keratomalacia and other symptoms.

W. S. REESE.

CIRCUMSCRIBED MELANOSIS AND PIGMENTED NEVI OF SURFACE OF CORNEA. A. PILLAT, Klin. Monatsbl. f. Augenh. **104:** 39 (Jan.) 1940.

The author reports on 4 cases of superficial, circumscribed melanosis of the cornea and on 1 case of a pigmented nevus in the cornea. Unlike nevi, the deposits of melanosis are flat pigmentations in the corneal epithelium; they may be linear, triangular or sector shaped, extending from the limbus for a few millimeters into the cornea or even to the center of an otherwise clear cornea. The remaining parts of the eye show no abnormal pigmentation. The form, color and extent of the melanotic deposits remained unchanged during extended observation.

The pigment in the cornea, which contains no blood vessels, is due to formation of melanin in the melanoblasts, independently of the presence of blood and lymph. No impairment of vision was noted in these cases.

K. L. STOLL.

CLINICAL AND MICROBIOLOGIC OBSERVATIONS ON EPIDEMIC KERATOCONJUNCTIVITIS. A. MEESMANN and W. BACHMANN, Klin. Monatsbl. f. Augenh. **105:** 1 (July) 1940.

The authors observed about 250 patients with epidemic keratoconjunctivitis at the ophthalmic clinic of the University of Kiel between August 1939 and February 1940. Almost half had been infected at the same factory; the other half were from scattered parts of Schleswig-Holstein. Several nurses, orderlies and resident patients at the clinic were infected. Similar observations were made in other cities, where the course of the disease was similar. A few peculiar symptoms not reported previously were observed. As is not the case with other types of conjunctivitis, the caruncle was initially swollen and reddened and the plica semilunaris showed glossy swelling. Photophobia, epiphora and, incidentally, distinct ptosis were observed from the third or fourth day. The conjunctiva of the tarsus showed early diffused swelling and numerous follicles beginning to develop at the upper fornix. The same changes appeared in the lower lid. Swelling of the preauricular gland was observed in cases of severe involvement. The follicles, subsiding as promptly as they had developed, disappeared within two to three weeks. General symptoms, such as headache and fatigue, occurred. The milder the course was, the earlier epithelial lesions were noted in the center of the cornea and the intermediary zone, but these were rarely seen toward the limbus. Fluorescein and bengal rose failed to stain specimens from these epithelial lesions except in the late stage in a few cases. In another small group of cases the epithelial defects involved the deeper layers and recovery took from four to five months. Slight pitting of the cornea resulted, due apparently to absorption of destroyed material of Bowman's membrane and of lamellas of the corneal surface. Irregular astigmatism resulting from this process reduced the vision occasionally to from 5/7.5 to 5/10. The period of incubation was not less than eight days. Immunity to recurrences probably does not exist. No new therapeutic information was gained, and the effect of touching up with silver nitrate in attempts to prevent corneal foci was doubtful. Cultures showed slowly growing diphtheroid bacilli (xerosis bacteria) and Staphylococcus aureus haemolyticus in symbiosis. Uncertainty remained as to whether these bacteria were the actual cause of epidemic keratoconjunctivitis. The ability of fluorescence with microscopic examination to demonstrate a filtrable virus was doubted. Solutions of diphtheria serum of 1:1,000 and later of 1:100 were instilled in the eyes and succeeded in eliminating the disease within a few days providing they were employed at an early stage. Too early discontinuation of this treatment having resulted in recurrences, the authors recommend that it be continued for three weeks, even if the symptoms have disappeared.

K. L. STOLL.

THERAPY OF EPIDEMIC NUMMULAR KERATITIS. ROGGENKÄMPER, Klin. Monatsbl. f. Augenh. **105:** 109 (July) 1940.

An efficient treatment for epidemic nummular keratitis has not been found. Bactericidal and astringent preparations appear to have an irritating and exacerbating effect. Epinephrine hydrochloride in a concentration of one tenth of the 1:1,000 solution yielded satisfactory results in 20 cases without other therapy; the follicles disappeared after a few days and the superficial corneal infiltration of the beginning stage subsided promptly without further spreading of the subepithelial opacities. Coin-shaped opacities did not develop. The original corneal opacities cleared completely. No result was obtained in cases of advanced involvement. The early use of epinephrine is recommended.

K. L. STOLL.

CHANGE IN REFRACTION AFTER CORNEAL TRANSPLANTATION. A. VOLOKITENKO, Vestnik oftal. **17:** 213, 1940.

Twenty-four eyes in 19 patients with transparent taking of the transplant were examined by skiascopy, ophthalmometry and subjective methods. In some cases the radius of the curvature of the transplant was measured. In all cases frequent changes in refraction took place. Various possible causes of these changes are discussed by Volokitenko. His conclusions are as follows:

1. There was a change in refraction in all cases.

2. This was observed chiefly within the first year and in some cases within the first two years after keratoplasty.

3. In the majority of cases hypermetropia was noted; there was myopia in only a few.

4. In 8 cases there was an increase in the radius of the curvature of the transplant or of its flattening.

With the change in refraction the visual acuity was improving; it is therefore important to check the refraction frequently within the first two years in order to obtain the best possible vision.

O. SITCHEVSKA.

TREATMENT OF TRACHOMATOUS PANNUS BY TRANSPLANTATION OF CONSERVED SCLERA. Y. S. SHEIN, Vestnik oftal. **17:** 223, 1940.

Conserved tissues cause a biochemical reaction in the inflamed cornea and thus bring about clearing of pannus, according to Filatov's explanation. Since the sclera is absorbed slowly, it was assumed that it was the proper tissue for transplantation.

In 3 cases of trachomatous pannus a homoplastic transplantation of sclera conserved from forty-three to eighty-six hours in a refrigerator was done. The histories and the technic of the operation are given, and the following conclusions are drawn:

1. Cadaver's sclera conserved at a temperature of 2 to 4 C. is a good medium for transplantation in the treatment of trachomatous pannus.

2. The conserved sclera showed no tendency to absorption during the eleven months of observation.

3. The material is easy to obtain, and the technic is simple; so a large number of oculists can use the method.

4. The scleral transplant was fixed to the rectus muscles after Filatov's method.

5. The operation gave good results as to both improvement of vision and clearing of the pannus, which had not responded to ordinary methods of treatment.

O. SITCHEVSKA.

A FAMILY WITH GROENOUW'S KERATITIS. H. MALLING, Acta ophth. **18:** 58, 1940.

The author briefly describes Groenouw's corneal dystrophy. The finding of a typical lesion in a boy aged 17 led to an examination of three generations of the family. The disease was found in twelve members. Inheritance of the defect seemed dominant in type.

O. P. PERKINS.

## Experimental Pathology

EXPERIMENTAL AND CLINICAL STUDIES IN HYDROCEPHALUS. J. Q. GRIFFITH, W. E. FRY and A. MCGUINNESS, Am. J. Ophth. **23:** 245 (March) 1940.

Previous work is referred to and briefly discussed and the following summary given:

"When thorotrast [colloidal thorium dioxide] is injected into the cisterna magna of the rat it spreads about the subarachnoid space and usually enters the ventricles. From the subarachnoid space it extends along the perineural pathways, especially those of the optic nerves, outlining them as seen in the roentgenograms. From the ventricle it is absorbed along the perivascular spaces of the vein of Galen and its tributaries, probably eventually reaching the spaces about the straight sinus, the lateral sinus, the internal jugular vein, and draining to the cervical lymph nodes. Thorotrast outlines the perivascular space of the vein of Galen more regularly after injection into the ventricle than after intracisternal injection. Hydrocollag injected into the ventricle may be identified histologically in the perivascular space of the vein of Galen.

"An intracisternal injection of kaolin tends to block the perineural optic space and, less regularly, the perivascular space of the vein of Galen. Thus a subsequent injection of thorotrast does not regularly outline these spaces. Blood from a subarachnoid hemorrhage has the same effect as kaolin, but acts less efficiently. Papilledema results if there is increased flow of fluid, or transmission of increased pressure, along a patent perineural optic space. This occurs in obstruction of the aqueduct; therefore, papilledema is associated with noncommunicating hydrocephalus. Communicating hydrocephalus is associated with, and is possibly caused by, block of both perineural absorption and of perivascular absorption from the ventricle. Therefore papilledema does not usually occur in communicating hydrocephalus. Analysis of clinical material showed that 45 out of 49 cases conformed to these conclusions drawn from the experimental data."

W. S. REESE.

ANIMAL EXPERIMENTS AS A CONTRIBUTION TO THE QUESTION OF THE ORIGIN OF EPIDEMIC NUMMULAR KERATOCONJUNCTIVITIS. G JANCKE, Klin. Monatsbl. f. Augenh. **105:** 7 (July) 1940.

Descriptions of the corneoconjunctival inflammation which appeared simultaneously in several districts of Germany in 1938 tally, but the nomenclature varies and the type of this disease has not been unanimously recognized. Jancke accepts Meisner's term keratoconjunctivitis nummularis epidemica, as the corneal efflorescences resemble those of keratitis nummularis as described by Dimmer. He experimented with 86 rabbits and 22 guinea pigs with the purpose of clearing doubts relative to transmission of the disease and its cause. He found that a causative agent exists and that it can be transmitted by ocular vaccination from one animal to another. The virus is not as malignant for animals as for human beings, and many animals appeared to be immune. Spontaneous transmission from animal to animal did not occur even though healthy and diseased animals were kept together. The virus could not be demonstrated with an ordinary microscope. Slight lesions of the corneal epithelium favor the onset of the disease. Some animal experiments showed positive results only when corneal lesions preceded vaccination. Keratoconjunctivitis developed also in patients who had suffered an accidental or surgical injury or a slight lesion during tonometric examination.

Corneal efflorescences strongly resembling those of keratitis of the disciform, superficial and dendritic types appeared during animal experiments, which suggests some relation to the virus of herpes. Diminished sensitivity of the cornea occurred frequently. Typical herpetic changes were observed occasionally in clinical patients with keratoconjunctivitis, and vice versa. Individual disposition seems to play a role in the appearance of this type of keratoconjunctivitis. The virus appears to be related to the herpes virus or to a similar ultravisible virus.

K. L. STOLL.

## General

CONTACT SHELLS MADE OF ARTIFICIAL SUBSTANCES. I. VON GYÖRFFY, Klin. Monatsbl. f. Augenh. **104:** 81 (Jan.) 1941.

The author experimented with contact shells manufactured of perfectly clear and unbreakable resin. This resin is an organic combination, the methyl ester of acrylic acid, consisting of large molecules developed out of a simple molecular unit by way of polymerization, or condensation. The chemical derivation and synthesis are described. This material is softer than glass; therefore, it is more readily scratched, its only disadvantage. Made of methyl acrylate, the shells are borne well by the eye; irritation of the eyeball has never been observed. They have the following advantages over glass shells: Being unbreakable, they may be made of very thin lamellas; they may be formed under a comparatively low temperature; their manufacture is simple; they are lighter in weight than glass; they are elastic to a certain extent.

K. L. STOLL.

## General Diseases

CHANGES IN THE FUNDUS OCULI FOLLOWING SPLANCHNECTOMY IN MALIGNANT HYPERTENSION. F. T. TOOKE and J. V. V. NICHOLS, Brit. J. Ophth. **25:** 97 (March) 1941.

Of 400 patients with cardiovascular hypertension, 100 on whom examination of the fundus oculi was performed were classed clinically and ophthalmoscopically as having essential hypertension. Of these, 20 were operated on by the method of Penfield and Cone, but it was possible to follow up but 15. From every standpoint, including that of the fundus oculi, 2 were cured, 3 were markedly improved and the condition of 1 was unchanged. However, the improvement in the fundus oculi was the most dramatic. An absence of changes in the fundus was noted both before and after operation in 37 per cent.

It may be stated that this operation is disappointing in its effect on the blood pressure but that the patients are improved when one takes into consideration symptoms and the condition of the fundus.

The article contains brief reports of the 15 cases. A description is given of the pathologic changes in the eye of a patient who died without operation of malignant hypertension with hypertensive heart disease and nephritis with generalized arteriosclerosis.

The article is illustrated.

W. ZENTMAYER.

RECURRENCES IN TUBERCULOUS DISEASES OF THE EYE. W. HALLERMANN, Klin. Monatsbl. f. Augenh. **104:** 387 (April) 1940.

The causation of recurrences in all tuberculous diseases is still uncertain. The changing clinical course of intraocular tuberculosis invites study of the frequently observed improvements and exacerbations. Recurrences may be brought on by so-called intercurrent diseases, such as colds, angina, bronchitis and bronchopneumonia. Other causes, physiologic but weakening the body temporarily, are menstruation, partus and puerperium. Exposure to strong sun rays is known to cause relapses. Hallermann studied the climatic influences on 572 patients of the Höchenschwand Sanitarium in the Black Forest. The apparent causes of the recurrences in 135 of the 572 patients are shown in tables and classified in the text. He concludes that atmospheric influences, among the many exogenous and endogenous causes, are of decided importance in rendering the course of tuberculosis so changeable. Observations continued for many years will reveal the connections. Data obtained are being used therapeutically and promise further progress in the treatment of tuberculosis.

K. L. STOLL.

A CASE OF SCLEREDEMA WITH OCULAR COMPLICATIONS. A. STENBECK, Acta ophth. **18:** 76, 1940.

The author gives a clinical and pathologic description of the rare dermatologic disease which Buschke in 1900 termed scleredema.

A woman aged 66 was thought to be afflicted with this condition. Briefly, the principal ophthalmologic complications consisted of a hard infiltration of both right eyelids, great edema of the bulbar conjunctiva and proptosis of 8 mm., with the vision reduced to 20/100. The fundus was normal. In the course of four months the right cheek became

swollen and the pharyngeal wall became thickened, so that it moved with difficulty. The indurated area gradually extended until it reached from the angle of one jaw to that of the other and from the chin to the jugular fossa. Death followed shortly as a result of intestinal ileus.

At autopsy the subcutaneous fatty tissue of the throat was found to be rich in connective tissue, which penetrated into the underlying muscles. Thick fibrous tissue was found also in the upper portion of the peritoneal cavity, surrounding the kidneys and adrenal glands and lying between the liver and the diaphragm. The orbital tissue was not edematous but was found to be largely converted into connective tissue, which formed a thick sheath around the optic nerve. This new-formed tissue was light and fine fibered and contained peculiar small bodies staining like fibrin and thought probably to represent degenerated products of collagenous fibers. The brain and the pituitary body were grossly normal.

O. P. PERKINS.

## General Pathology

OCCURRENCE OF MAST CELLS IN THE HUMAN EYE IN VARIOUS PATHOLOGIC CONDITIONS. H. HOLMGREN and A. STENBECK, Acta ophth. **18:** 271, 1940.

Twelve eyes, removed for various reasons, were studied by the authors after appropriate fixing and staining. The results are summarized as follows:

1. Few mast cells are observed in the normal cornea. They are more frequent in cases of such conditions as ulcus serpens. A slight increase was observed in 2 cases of chronic iridocyclitis.

2. The normal cornea stained with toluidine blue solution shows clear, diffuse metachromasia. At the limbus this decreases, passing into the fainter metachromasia of the sclera.

3. An increase in the number of mast cells was observed in cases of iritis and of glaucoma.

4. In the choroid mast cells may be few or many. In 1 case of glaucoma they were plentiful.

5. The mast cells show a striking tendency to form in groups around blood vessels; the cells lying near the blood vessels seem to contain fewer granules than do those at a distance.

6. The granule content of the mast cells varies in different regions; the cells in the iris as a rule contain fewer granules than do cells in other parts of the eye. The form of the cells varies with the tissue in which they lie.

O. P. PERKINS.

## Glaucoma

FIELD CHANGES AFTER SATISFACTORY FILTRATION OPERATIONS FOR GLAUCOMA. J. W. BURKE, Am. J. Ophth. **23:** 657 (June) 1940.

From a survey of his office records of surgical cases of glaucoma Burke draws the following conclusions:

"(1) In filtration glaucoma operations that have been successfully performed we may expect a gradual further loss of the visual field

over a long period of years in about 50 per cent of the cases. To be sure, this loss does not take place so rapidly as it would if the patients had not been operated upon. Most of these patients will retain central fixation and useful vision in spite of advancing field changes. (2) The type of field defect continues, instead of a new one occurring. (3) We are not justified in hesitating to operate because the fixation area has been invaded—a procedure regarded as dangerous by some surgeons. Although occasionally the process continues, and the point of fixation, or even total vision, is lost, as in case 21, on the other hand, in most instances, as in cases 8, 10, 13, and 33 O. D., the destructive process ceases and useful vision is retained. (4) Early operative interference is the best assurance that no further damage will be inflicted on the visual field. Although this is not always true, as is demonstrated in cases 25, 31, 32 and 33, O. S., yet the fields are best retained in those cases in which little damage has been suffered before operation."

W. S. Reese.

Further Metabolic Research on Patients with Glaucoma: Report of Cases. H. Schmelzer, Klin. Monatsbl. f. Augenh. **104:** 722 (June) 1940.

This is the continuation of a previous report on 55 patients with glaucoma and on 45 healthy persons of corresponding ages with normal intraocular tension. The present series consists of 23 patients with primary glaucoma and 25 persons with normal intraocular tension for controls. Only blood removed after the subjects had fasted was used for tests; the patients and the controls were of corresponding ages and their living standards were approximately the same. In two tables are presented the results of the investigations on the basis of age, diagnosis, blood pressure, metabolic rate and content in the blood of uric acid, sugar, indican, bilirubin, cholesterol, xanthoprotein and residual nitrogen. Most of the patients had hypercholesteremia and gave a positive reaction to the xanthoprotein test. The content of residual nitrogen, on the other hand, was normal in the patients with glaucoma, indicating that no renal lesion was present but that the function of the liver was disturbed.

K. L. Stoll.

## Injuries

Symptomatology and Therapy of Belated Ocular Lesion Due to Mustard Gas. W. Zettl, Klin. Monatsbl. f. Augenh. **104:** 217 (Feb.) 1940.

Zettl reports on the case of a combatant who was injured by the explosion of a bomb in 1918. His gas mask was damaged, and chronic conjunctivitis due to dichlorodiethyl sulfide developed. His eyes were free from disturbances, except slight impairment of vision, until the conjunctivitis recurred without apparent cause in 1924 and, again, in 1935. In April 1939 severe conjunctivitis with "mustard gas varices" was observed; it was followed by corneal ulcers, lime concretions and

atrophy of the conjunctiva. Surgical abrasion of the cornea and removal of the lime deposits were futile. Implantation of a flap of labial mucosa after Denig's method brought recovery.

K. L. STOLL.

## Lids

EUCALYPTUS IN THE TREATMENT OF BLEPHARITIS. A. MIKHAILOV, Vestnik oftal. **17:** 296, 1940.

An alcohol tincture of eucalyptus leaves was used by Mikhailov in treating 50 patients with severe blepharitis for whom all routine measures had been of no avail. Ten to fifteen daily applications with a cotton applicator to the lid margins were sufficient to heal ulcerative blepharitis.

O. SITCHEVSKA.

## Lens

THE CHI-SQUARE TEST OF SIGNIFICANCE APPLIED TO A SERIES OF INTRA-CAPSULAR CATARACT EXTRACTIONS. W. J. B. RIDDELL, Brit. J. Ophth. **25:** 49 (Feb.) 1941.

Riddell supplies the following summary of his paper:

"In a series of 122 senile cataract extractions the intracapsular method was considered to be suitable in 88. The results have been treated statistically by the $X^2$ test of significance. The sex ratio observed, the treatment of hospital and private patients, the treatment of right and left eyes and of the sexes have all been considered. A better visual result was found where the lens was removed intact within its capsule than in those cases where the capsule ruptured. Rupture of the capsule occurred evenly throughout the series and in all the age groups. Evidence is presented to show that the better visual results tend to occur below rather than over the age of 65, and that this is not necessarily attributable to the type of operation. Comparison is made with fifty patients in whom the operation intended was a simple extraction with a peripheral iridectomy followed by early capsulotomy. The intact intra-capsular cases gave the better visual result and those which ruptured did not differ significantly from the control group. In eight patients the two eyes were submitted to the different operations."

W. ZENTMAYER.

ECTOPIC LENS LOCATED LATER ON THE OPTIC DISK: REPORT OF A CASE. K. T. MEYER, Klin. Monatsbl. f. Augenh. **104:** 436 (April) 1940.

This is the follow-up of a case of migrating lens resulting from congenital ectopia of the lens reported by Vormann (*Ztschr. f. Augenh.* **75:** 160 [Sept.] 1931). A boy aged 2 in 1925 showed bilateral ectopia of the lens. He was examined in 1925 and reexamined in 1931 and again in 1938 by Meyer, who observed that the lens in one eye was perfectly clear and located directly over the disk, to which it appeared to be attached. The lens remained in this location during six months of observation, although cyclodialysis was performed for increased intraocular tension.

K. L. STOLL.

## Neurology

RELATION OF SYPHILITIC OPTIC ATROPHY AND PAPILLEDEMA TO ADHESIONS AT THE CHIASM: INDICATIONS FOR AND RESULTS OF SURGICAL TREATMENT. L. HAUSMAN, Arch. Neurol. & Psychiat. **43:** 1034 (May) 1940.

The following series of cases is presented to emphasize the need for keeping in mind the occurrence of arachnoid adhesions around the chiasm in cases of syphilis, as well as to point out the indication for surgical intervention in these cases and the benefits of this procedure in the restoration or improvement of vision.

*Group 1.*—The clinical picture was characterized by bilateral primary optic atrophy; heteronymous visual defects, when the patient was not totally blind; a normal ventricular system, and no evidence of increased intracranial pressure. Adhesions were present around the optic chiasm and nerves in all 3 cases.

*Group 2.*—The clinical picture was characterized by secondary optic atrophy and internal hydrocephalus. No unusual adhesions were observed around the chiasm.

*Group 3.*—The picture was characterized by papilledema without internal hydrocephalus. Adhesions were present around the optic chiasm.

*Summary.*—In cases of the type of group 1, adhesions around the optic chiasm and nerves should be suspected and treated surgically. In cases of the type of group 2, it would seem that exploration of the chiasm is not indicated. The findings in group 3 indicate that in cases of this type exploration of the chiasm is warranted.

R. IRVINE.

THE VISUOPSYCHIC APPARATUS AND THE ACCOMMODATION REFLEX. R. Y. HERREN, Arch. Neurol. & Psychiat. **43:** 1185 (June) 1940.

The case reported is that of a strongly right-handed man who for several years had had peripheral blindness in the left eye. A tumor developed in the left occipital portion of the brain in the course of treatment, for which the major portion of Brodmann's areas 18 and 19 of the left hemisphere was removed, area 17 being left intact. Postoperatively mind blindness developed, but the patient retained his ability to receive visual sensory impressions. The mechanism for light reaction and probably that for accommodation were intact.

A discussion follows of mind blindness and the probable pathways for the accommodation reflex.

R. IRVINE.

ASSOCIATION OF HOMONYMOUS HEMIANOPIA AND UNILATERAL ABSENCE OF ALPHA WAVES. T. J. CASE, Arch. Neurol. & Psychiat. **43:** 1273 (June) 1940.

In March 1938, absence of or marked difference in the alpha waves on the two sides of the brain as a criterion in the diagnosis of intracranial tumors was discussed (Localization of Cerebral Cortical Lesions by Electroencephalographic Examination, *Arch. Neurol. & Psychiat.* **40:** 623 [Sept.] 1938). Since, 8 cases have been observed in which this absence of or difference in the alpha waves was present; in all of them homonymous hemianopia was noted.

Operations in 5 of the 8 cases have revealed the approximate position of the lesion. In 2 of them there was a tumor of the temporal lobe, in 1 a traumatic cyst of the temporal lobe, in 1 a tumor of the occipital lobe and in 1 an intraventricular tumor which involved the optic radiations.

The common features of the 5 cases were involvement of the optic radiations and homonymous hemianopia. These cases suggest that the alpha waves may be a cyclic electrical phenomenon circulating in a chain of neurons, one link of which is the optic radiations. Unilateral loss of occipital alpha waves is associated with homonymous hemianopia, both probably resulting from destruction of the optic radiations.

Unilateral loss of the occipital alpha waves or a gross difference in the size of these waves on the two sides constitutes a sign of signal importance in the diagnosis of lesions of the temporal and occipital lobes.

R. IRVINE.

## Trachoma

TRACHOMA. R. E. WRIGHT, Brit. J. Ophth. **24:** 547 (Nov.) 1940.

Wright reports some experimental data of clinical interest from the records of a combined etiologic investigation by various members of the Government Ophthalmic Hospital and the King Institute of Preventive Medicine, Madras, 1935, 1936 and 1937.

Details of the experiments are given in tabular form. These further attempts to cultivate a virus are inconclusive. As certain definite lesions were produced with trachoma material which may have been due to a trachoma virus, it is desirable that work on these lines should be repeated.

It would appear that under experimental conditions gross contamination of the normal human conjunctiva with material from the conjunctivas of persons suffering from a condition judged to be trachoma by accepted clinical and microscopic standards does not produce the condition with the frequency which orthodox clinical and epidemiologic teaching might lead one to expect.

In the investigation of this disease, observations—whether clinical or experimental—are so liable to fallacious interpretation that unless carefully controlled they are likely to lead to erroneous conclusions.

Correct conclusions cannot be drawn from insufficient numbers of observations. This experimental axiom often appears to be overlooked by clinical and experimental observers in connection with investigations on trachoma.

The nature of trachoma, perhaps more accurately regarded as a congeries of trachomatoid disturbances of the conjunctiva, remains obscure.

W. ZENTMAYER.

## Tumors

BILATERAL PLEXIFORM NEUROMATA OF THE CONJUNCTIVA AND MEDULLATED CORNEAL NERVES. M. P. KOKE and A. E. BRALEY. Am. J. Ophth. **23:** 179 (Feb.) 1940.

Koke and Braley report the case of a 28 year old white man who had paroxysmal attacks of hypertension due to a pheochromocytoma of the right adrenal gland. The tumor was removed, and there were

no further attacks. The patient was found to have also plexiform neuromas of the palpebral and the bulbar conjunctivas and bilateral medullation of the corneal nerves. The authors suggest that the ocular abnormalities may have been due to or at least related to the adrenal tumors.

W. S. REESE.

METASTATIC CARCINOMA OF THE IRIS CLINICALLY SIMULATING GUMMA. H. B. STALLARD, Brit. J. Ophth. **24**:541 (Nov.) 1940.

The patient was a man aged 57 years. The left eye showed a pink-buff hemispheric mass projecting into the anterior chamber "between 9 and 10:45 o'clock," at the filtration angle. It came forward from the root and the anterior surface of the iris. Its summit was vascular, and a grayish white trail hung down into the anterior chamber. There were a posterior synechia and deposits on Descemet's membrane. There were pigment granules over the walls of the anterior chamber. There were a history of syphilis and a positive Wassermann reaction. A diagnosis of gumma and syphilitic iritis was made. One month later a swelling occurred in the right supraclavicular fossa. A roentgenogram showed a shadow in the right bronchus. There was a weakness of the left upper and lower extremities. Three months after onset of the ocular symptoms the patient died in coma. Postmortem examination showed a primary carcinoma of the bronchus with massive infiltration of the tracheobronchial, posterior mediastinal and abdominal lymph nodes. Multiple metastases were found in the abdominal viscera and in the brain.

Sections from the nodes in the various tissues involved showed an oat cell carcinoma. The growth in the iris was an adenocarcinoma.

The article is illustrated.

W. ZENTMAYER.

## Therapeutics

LOCAL APPLICATION OF COD LIVER OIL IN CASES OF KERATOMALACIA. B. RADZIKHOVSKIJ, Vestnik oftal. **16**:434, 1940.

Cod liver oil was applied locally to 13 children (23 eyes) aged from 6 months to 2 years. In 9 of these children keratomalacia was the result of severe catarrh of the gastrointestinal tract; in 4 it followed measles. The lesions of the cornea varied from superficial abrasions to destruction of one third of the cornea with a descemetocele.

The therapeutic effect was noted in the first days of the treatment. In cases of severe involvement the progress of the ulceration was stopped; the time of the treatment was shortened considerably, and no perforation of the cornea was observed. The local action of cod liver oil in cases of keratomalacia is favorable because of the local vitamin A insufficiency and because of the bactericidal qualities of the substance.

O. SITCHEVSKA.

# Society Transactions

EDITED BY DR. W. L. BENEDICT

## NEW YORK ACADEMY OF MEDICINE, SECTION OF OPHTHALMOLOGY

ALGERNON REESE, M.D., *Chairman*

BRITTAIN PAYNE, M.D., *Secretary*

*Feb. 17, 1941*

**Anatomy and Functional Significance of Primary Endings of Optic Nerve in Man and in Animals.** DR. OTTO MARBURG (by invitation).

The terminations of the optic nerve are in the optic thalamus and the midbrain, the former receiving four groups of fibers:

1. Fibers extend into the geniculate body; others extend into the substantia grisea pregeniculata. The former conduct all the visual impressions to the calcarine cortex, whereas the latter are connected with the midbrain only, according to T. J. Putnam.

2. Evidence is practically sufficient to account for the nonmyelination of the fibers extending into the pulvinar. The medial nucleus of the optic thalamus receives the tractus retinothalamicus anterior and posterior.

3. There is a possible connection with the subthalamic body, a fasciculus retinosubthalamicus, which reacts to tonic stimuli.

4. The hypothalamus is connected with the tractus retinothalamicus and the two fasciculi which form the tractus retinotuberis. These tracts are connected secondarily with the hypophysial gland and exert their influence on the vegetative nervous system.

The tractus retinotectalis in the midbrain connects with the anterior colliculi and controls the reflexes of attention. An additional fasciculus, the tractus retinoisthmicus, is present in man and accounts for the simultaneous impressions from the optic and from the acoustic nerve. The ventral optic tract ends near the oculomotor root in the nucleus opticus mesencephali ventralis.

DISCUSSION

DR. HENRY ALSOP RILEY (by invitation): It is almost impossible to associate function with the anatomy of all the fibers, tracts and nuclei of the central nervous system in adult man. These structures are inheritances from prehistoric times, and in many instances they are primitive and undeveloped. Certain alterations to fit changing conditions have been necessary, but many of the older structures remain with function diminished or inactive.

DR. ELIOTT B. HAGUE (by invitation), Buffalo: In the hypothalamus, nuclear structures are more clearly demonstrable in terms of cellular type than in terms of cellular aggregations. In man at least, as Morgan has stated, most of the nuclei in this region are rather diffuse and may be identified more readily in terms of cell type than in terms of the classification based on topographic arrangement. I want to ask Dr. Marburg whether the nuclei he describes are discrete or diffuse.

DR. OTTO MARBURG: The hypothalamic nuclei are easy to differentiate according to their site and circumscribed shape; in addition, the form of the cells permits some differentiation. The nuclei represent an interruption of the fibers on their way from the retina to the hypophysis, a way which is direct in frogs.

In reply to Dr. Hague's question, the nuclei are not diffuse.

**A Procedure in Intracapsular Cataract Extraction.** DR. DANIEL B. KIRBY.

An original method of rupturing the superior zonule of the crystalline lens in certain cases of immature cataract has some advantage over ordinary pressure and traction in delivering the lens in the capsule. A corneal suture is placed near the upper limbus before a fairly large incision is made and is enlarged with scissors. An iridectomy is performed, the cornea is retracted with the suture and the blunt end of a small squint hook is used to break the anterior zonule. After some manipulation the lens is expressed with considerable ease. The procedure has been satisfactory over a period of four years.

**Return of Vision in the Vertebrate Eye Following Repeated Transplantations.** (Illustrated Motion Picture). PROF. L. S. STONE (by invitation).

Function returned within three months to each adult salamander eye repeatedly transplanted. Retinal degeneration in three weeks was followed by regeneration from the ora serrata. A new retina and a new optic nerve were completed within two months. In one species (Triturus viridescens) the lens degenerates and is replaced by one derived from the dorsal part of the iris. This peculiar lens replacement, lacking in other vertebrates, can be initiated in an iris graft in the presence of a normal lens. This is unique, since further experiments (inducement of lenses and cyclopia) demonstrated that the embryonic lens is determined by induction from an eye-forming center.

**Special Features of Ocular Blood Vessels.** DR. ROBERT K. LAMBERT.

The effect of intraocular pressure on the structure of the blood vessels of the uveal tract and the retina was demonstrated by differential staining and fixation. It was found that sclerotic changes in the walls of the ocular vessels differed somewhat from changes in other vessels of the body.

DISCUSSION

DR. ALGERNON REESE: Why should there be afferent vessels to Schlemm's canal?

DR. ROBERT K. LAMBERT: Friedenwald made the observation in 1936 that there are afferent and efferent vessels, and his idea of drainage from the eye was that these vessels supply the plasma to Schlemm's canal, which controls the drainage of the aqueous.

DR. ALGERNON REESE: Dr. Lambert spoke of the marked thickness of the walls of the postciliary vessels and of the frequent sclerosis of these vessels. It is known that the blood vessels of the iris are normally sclerosed. As Dr. Lambert stated, the sclerosis probably serves as a splint for the vessels, thereby preventing any tendency to kink during the constant movement of the iris. Does Dr. Lambert suppose that the postciliary vessels likewise have such walls to overcome any tendency to kinking during the constant movement of the eyes, which in one direction makes the vessels taut and in the opposite direction makes them tortuous?

DR. ROBERT K. LAMBERT: I think that they do is a good assumption. The only difference is that the vessels of the iris have much more connective tissue and the ciliary vessels have much more muscle and are convoluted and tortuous.

The vessels of the iris have been a puzzle to many pathologists, who have become greatly interested in their appearance. These investigators had not given much previous thought to them and seemed to think that the only vessels with similar walls were those of the spleen, where there is likewise much motility, the amount depending on how much blood there is in the organ.

## CASE REPORTS

**Kayser-Fleischer Ring Associated with Hepatolenticular Degeneration: A Report of 6 Cases.** DR. SAMUEL GARTNER (by invitation).

This article is published in full in this issue of the ARCHIVES, page 595.

**Hemangioma of the Orbit.** DR. DONALD W. BOGART (by invitation).

A tumor measuring 15 by 15 mm. and extending almost to the apex of the orbit was successfully removed from the region between the upper nasal aspect and the right side of the orbit. The mass was attached to the medial rectus, superior oblique and levator palpebrae superioris muscles. It collapsed and bled considerably on removal. Histologic examination revealed a hemangioma, with fatty replacement of voluntary muscle. The unusual position of the tumor combined with involvement of the levator muscle required a resection at a later date to correct the ptosis.

**Squamous Cell Carcinoma of the Cornea.** DR. SAMUEL EVANS (by invitation).

This article will be published in full, with discussion, in a later issue of the ARCHIVES.

# Book Reviews

**Transactions of the Ophthalmological Society of Australia.** (British Medical Association.) Vol. 1. Pp. 146, with 101 illustrations. Sydney, Australia: Australasian Medical Publishing Co., 1939.

The first meeting of the recently formed Ophthalmological Society of Australia was held on April 5, 1939, in Melbourne, and this is the report of the proceedings.

The presidential address was given by Sir James Barrett and dealt with blindness, partial sightedness and the history of Braille type.

O'Day reported on his researches on the visual cells of Australian reptiles and mammals. He concluded that the early reptiles because of their diurnal habits discarded the rods they inherited from the amphibians and from the fishes. Some of the work—notably that on the Pygopodidae—is here reported for the first time. The same author described the hot celloidin technic of embedding histologic tissues.

In a paper remarkable for the excellence of the photomicrographs, Willis made a plea for the histologic study of ocular tissues by nonsection methods. He used stripped and teased material and showed how the structures are more nearly preserved when such material is used.

Maynard gave a preliminary report of his work on experimental intraocular hemorrhage. He injected blood into the eyes of rabbits and killed the animals at certain periods thereafter. He found that the fluid constituents of the blood are removed via the anterior chamber and the optic nerve.

Trethewie discussed the influence of acetylcholine on the ocular tissues. He pointed out that the drug is rapidly destroyed in vivo and suggested that a more stable ester, such as mecholyl or doryl, be employed.

Marks, Willis and Anderson reported a case of glioma of the optic disk. This tumor was an astrocytoma and not, as might be inferred from the title, a retinoblastoma.

Niall reported 6 cases of malignant exophthalmos in association with Graves's disease. He stated that the Naffziger operation is the procedure of choice.

Measurement and simultaneous recording of proptosis by a photographic method was described by Brew.

Tostevin described his method of dealing with recurrent bullous keratitis. He said that the epithelium should be curetted off and the cornea lightly treated with phenol. In cases of stubborn inflammation he has trephined the eyes with good results.

Before showing a film supplied by Castroviejo, North described the technics of the leading exponents of corneal transplantation.

Bruce Hamilton reported fully on investigations carried out under the Commonwealth National Health and Medical Research Council on birth injuries to the eyes. He said that the subject is a branch of preventive medicine and suggested that it be brought before the obstetric surgeons of the commonwealth.

Three cases of inflammatory pseudotumor of the orbit were reported by Duncan, and 3 real tumors of the orbit—carcinoma, sarcoma and glioma—were reported on by Black.

A complete exposition of the present status of contact glasses was given by Ida Mann, who also reported a case of congenital cystic eye.

One of the most interesting case reports was given by Duncan and Maynard, who described bilateral glioma in twins. Full postmortem observations were reported.

It is a pleasure to welcome a journal of such outstanding worth. The activities of this new society will furnish valuable contributions to ophthalmic literature.

G. M. BRUCE, M.D.

**Transactions of the Ophthalmological Society of Australia.** (British Medical Association.) Vol. 2. Pp. 114, with 3 illustrations. Sydney, Australia: Australasian Medical Publishing Co., 1940.

In spite of the war and the absence of several of its key members, the Ophthalmological Society of Australia continues to function vigorously. This volume of the transactions, reporting the second annual meeting, fulfils the promise made by its predecessor.

Counsell, who is now a wing commander in the Royal Australian Air Force, reported on air force standards and examination procedure. Of all applicants 11 per cent were rejected on account of ocular shortcomings, and of these 30 per cent were found to have defective vision. Color vision was found to be at fault in 29 per cent. Further studies on fusion were presented by Anderson and by Mann.

Squadron Leader Blakemore submitted a paper on the visual complications of high speed flying. The principal complication is the transient blindness known as a black-out. This is due to corticofugal-centrifugal force and varies from a graying or bluing of the vision to loss of light perception. It disappears when conditions return to normal, and no ill effects are encountered. The mathematical and physiologic factors are well covered in this most interesting paper.

Waddy told of his experiences in the last war, when he was an ophthalmologist with the Australian forces. He suggested that ophthalmologists in this war take along some equipment of their own, especially hand magnets. The same author read a paper on Krukenberg's spindle.

The work done in its first year by a committee formed to prevent blindness in Tasmania was outlined by Bruce Hamilton. An analysis of 639 of 6,770 cases studied was submitted. The author urged that the other states of the commonwealth undertake a similar survey. Hamilton also read an excellent paper on the Sjögren syndrome and keratitis sicca.

Phillips described the anatomy of the geniculate pathways and discussed electroencephalography.

Because 1 of his patients lost his sight from sympathetic ophthalmia, Anderson reviewed the literature on this disease. He concluded that the handling in his case was imperfect and stated honestly how it might have been improved.

Colvin reported on the successful treatment of trachoma by sulfanilamide and on the treatment of subluxation and dislocation of the lens. He advocated removal of trachomatous lenses by means of the loop.

Smith spoke of the value of ionization in the treatment of inflammatory disease and also expressed his personal views on glaucoma. He expressed a belief in early operation and a preference for the Lagrange sclerectomy.

North advocated the treatment of pterygium by application of a small Thiersch graft to the site of the excised growth.

Armstrong spoke of the Lexer operation for ptosis. This consists of connecting the frontalis muscle to the lid by means of narrow strips of fascia lata.

Sixty-five patients with glaucoma were studied by Macindoe. He stated a belief in early operation and expressed the opinion that trephining should be done even in cases of acute glaucoma.

G. M. BRUCE, M.D.

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## CORRECTION

In the article by Dr. Jesse M. Levitt entitled "Boeck's Sarcoid with Ocular Localization: Survey of the Literature and Report of a Case," in the September issue (ARCH. OPHTH. **26:** 358, 1941), in the first line on page 374 "metatarsal" should be substituted for "metacarpal." On page 388 in the first line of the last paragraph "present" should be substituted for "presents."

# Directory of Ophthalmologic Societies *

## INTERNATIONAL

### International Association for Prevention of Blindness

President: Dr. P. Bailliart, 66 Boulevard Saint-Michel, Paris, 6e, France.
Secretary-General: Prof. M. Van Duyse, Université de Gand, Gand, Prov. Ostflandern, Belgium.
All correspondence should be addressed to the Secretariat, 66 Boulevard Saint-Michel, Paris, 6e, France.

### International Ophthalmologic Congress

President: Prof. Nordenson, Serafimerlasarettet, Stockholm, Sweden.
Secretary: Dr. Ehlers, Jerbanenegade 41, Copenhagen, Denmark.

### International Organization Against Trachoma

President: Dr. A. F. MacCallan, 17 Horseferry Rd., London, England.

### Pan-American Congress of Ophthalmology

President: Dr. Harry S. Gradle, 58 E. Washington St., Chicago.
Executive Secretaries: Dr. Conrad Berens, 35 E. 70th St., New York. Dr. M. E. Alvaro, 1511 Consolacao, São Paulo, Brazil.

## FOREIGN

### All-India Ophthalmological Society

President: Dr. B. K. Narayan Rao, Minto Ophthalmic Hospital, Bangalore.
Secretary: Dr. G. Zachariah, Flitcham, Marshall's Rd., Madras.

### British Medical Association, Section on Ophthalmology

President: Dr. W. Clark Souter, 9 Albyn Pl., Aberdeen, Scotland.
Secretary: Dr. Frederick Ridley, 12 Wimpole St., London, W. 1.

### Chinese Ophthalmology Society

President: Dr. C. H. Chou, 363 Avenue Haig, Shanghai.
Secretary: Dr. F. S. Tsang, 221 Foochow Rd., Shanghai.

### Chinese Ophthalmological Society of Peiping

President: Dr. H. T. Pi, Peiping Union Medical College, Peiping.
Secretary: Dr. C. K. Lin, 180 Hsi-Lo-yen, Chienmeng, Peiping.
Place: Peiping Union Medical College, Peiping. Time: Last Friday of each month.

### German Ophthalmological Society

President: Prof. W. Lohlein, Berlin.
Secretary: Prof. E. Engelking, Heidelberg.

### Hungarian Ophthalmological Society

President: Prof. H. G. Ditroi, Szeged.
Assistant Secretary: Dr. Stephen de Grosz, University Eye Hospital, Maria ucca 39, Budapest.
All correspondence should be addressed to the Assistant Secretary.

### Midland Ophthalmological Society

President: Dr. W. Niccol, 4 College Green, Gloucester, England.
Secretary: Mr. T. Harrison Butler, 61 Newhall St., Birmingham 3, England.
Place: Birmingham and Midland Eye Hospital.

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* Secretaries of societies are requested to furnish the information necessary to make this list complete and keep it up to date.

NORTH OF ENGLAND OPHTHALMOLOGICAL SOCIETY

President: Dr. A. MacRae, 6 Jesmond Rd., Newcastle-upon-Tyne, England.
Secretary: Dr. Percival J. Hay, 350 Glossop Rd., Sheffield 10, England.
Place: Manchester, Bradford, Leeds, Newcastle-upon-Tyne, Liverpool and Sheffield, in rotation. Time: October to April.

OPHTHALMOLOGICAL SOCIETY OF AUSTRALIA

President: Dr. A. James Flynn, 135 Macquarie St., Sydney.
Secretary: Dr. D. Williams, 193 Macquarie St., Sydney.

OPHTHALMOLOGICAL SOCIETY OF EGYPT

President: Prof. Dr. Mohammed Mahfouz Bey, Government Hospital, Alexandria.
Secretary: Dr. Mohammed Khalil, 4 Baehler St., Cairo.
All correspondence should be addressed to the Secretary, Dr. Mohammed Khalil.

OPHTHALMOLOGICAL SOCIETY OF THE UNITED KINGDOM

President: Mr. T. Harrison Butler, 61 Newhall St., Birmingham 3, England.
Secretary: Mr. L. H. Savin, 7 Queen St., London, W. 1, England.

OPHTHALMOLOGY SOCIETY OF BOMBAY

President: Dr. D. D. Sathaye, 127 Girgaum Rd., Bombay 4, India.
Secretary: Dr. H. D. Dastur, Dadar, Bombay 14, India.
Place: H. B. A. Free Ophthalmic Hospital, Parel, Bombay 12. Time: First Friday of every month.

OXFORD OPHTHALMOLOGICAL CONGRESS

Master: Dr. Percival J. Hay, 350 Glossop Rd., Sheffield 10, England.
Secretary-Treasurer: Dr. F. A. Anderson, 12 St. John's Hill, Shrewsbury, England.

PALESTINE OPHTHALMOLOGICAL SOCIETY

President: Dr. Arieh Feigenbaum, Abyssinian St. 15, Jerusalem.
Secretary: Dr. E. Sinai, Tel Aviv.

POLISH OPHTHALMOLOGICAL SOCIETY

President: Dr. W. Kapuściński, 2 Waly Batorego, Poznań.
Secretary: Dr. J. Sobański, Lindley'a 4, Warsaw.
Place: Lindley'a 4, Warsaw.

ROYAL SOCIETY OF MEDICINE, SECTION OF OPHTHALMOLOGY

President: Dr. A. J. Ballantyne, 11 Sandyford Pl., Glasgow, C. 3, Scotland.
Secretary: Dr. C. Dee Shapland, 15 Devonshire Pl., London, W. 1, England.

SOCIEDAD OFTALMOLOGIA DEL LITORAL, ROSARIO (ARGENTINA)

President: Prof. Dr. Carlos Weskamp, Laprida 1159, Rosario.
Secretary: Dr. Juan M. Vila Ortiz, Córdoba 1433, Rosario.
Place: Rosario. Time: Last Saturday of every month, April to November, inclusive.
All correspondence should be addressed to the President.

SOCIEDADE DE OPHTALMOLOGIA E OTO-RHINO-LARYNGOLOGIA DA BAHIA

President: Dr. Francisco Ferreira, Pitangueiras 15, Brotas, S. Salvador, Brazil.
Secretary: Dr. Adroaldo de Alencar, Brazil.
All correspondence should be addressed to the President.

SOCIETÀ OFTALMOLOGICA ITALIANA

President: Prof. Dott. Giuseppe Ovio, Ophthalmological Clinic, University of Rome, Rome.
Secretary: Prof. Dott. Epimaco Leonardi, Via del Gianicolo, 1, Rome.

SOCIÉTÉ FRANÇAISE D'OPHTALMOLOGIE

Secretary: Dr. René Onfray, 6 Avenue de la Motte Picquet, Paris, 7e

SOCIETY OF SWEDISH OPHTHALMOLOGISTS

President: Prof. K. G. Ploman, Stockholm.
Secretary: Dr. K. O. Granström, Södermalmstorg 4 Ill tr., Stockholm, Sö.

TEL AVIV OPHTHALMOLOGICAL SOCIETY

President: Dr. D. Arieh-Friedman, 96 Allenby St., Tel Aviv, Palestine.
Secretary: Dr. Sadger Max, 9 Bialik St., Tel Aviv, Palestine.

## NATIONAL

AMERICAN MEDICAL ASSOCIATION, SCIENTIFIC ASSEMBLY, SECTION ON OPHTHALMOLOGY

Chairman: Dr. Lawrence T. Post, 508 N. Grand Blvd., St. Louis, Mo.
Secretary: Dr. Derrick Vail, 441 Vine St., Cincinnati.
Place: Atlantic City. Time: June 8-12, 1942.

AMERICAN ACADEMY OF OPHTHALMOLOGY AND OTOLARYNGOLOGY, SECTION ON OPHTHALMOLOGY

President: Dr. Frank R. Spencer, Physicians' Bldg., Boulder, Colo.
President-Elect: Dr. Ralph I. Lloyd, 14–8th Ave., Brooklyn.
Executive Secretary-Treasurer: Dr. William P. Wherry, 1500 Medical Arts Bldg., Omaha.
Place: Chicago. Time: Oct. 19-24, 1941.

AMERICAN OPHTHALMOLOGICAL SOCIETY

President: Dr. Allen Greenwood, 82 Commonwealth Ave., Boston.
Secretary-Treasurer: Dr. Eugene M. Blake, 303 Whitney Ave., New Haven, Conn.

ASSOCIATION FOR RESEARCH IN OPHTHALMOLOGY, INC.

Chairman: Dr. John Evans, 23 Schermerhorn St., Brooklyn.
Secretary-Treasurer: Dr. C. S. O'Brien, University Hospital, Iowa City.

CANADIAN MEDICAL ASSOCIATION, SECTION ON OPHTHALMOLOGY

President: Dr. Alexander E. MacDonald, 170 St. George St., Toronto.
Secretary-Treasurer: Dr. L. J. Sebert, 170 St. George St., Toronto.

CANADIAN OPHTHALMOLOGICAL SOCIETY

President: Dr. J. Vaillancourt, 46 St. Louis St., Quebec.
Secretary-Treasurer: Dr. Alexander E. MacDonald, 421 Medical Arts Bldg., Toronto.

NATIONAL SOCIETY FOR THE PREVENTION OF BLINDNESS

President: Mr. Mason H. Bigelow, 1790 Broadway, New York.
Secretary: Miss Regina E. Schneider, 1790 Broadway, New York.
Executive Director: Mrs. Eleanor Brown Merrill, 1790 Broadway, New York.

## SECTIONAL

ACADEMY OF MEDICINE OF NORTHERN NEW JERSEY, SECTION ON EYE, EAR, NOSE AND THROAT

President: Dr. Charles W. Barkhorn, 223 Roseville Ave., Newark.
Secretary: Dr. William F. McKim, 317 Roseville Ave., Newark.
Place: 91 Lincoln Park South, Newark. Time: 8:45 p. m., second Monday of each month, October to May.

CENTRAL WISCONSIN SOCIETY OF OPHTHALMOLOGY AND OTOLARYNGOLOGY

President: Dr. J. V. May, 1703 Main St., Marinette.
Secretary: Dr. G. L. McCormick, 626 S. Central Ave., Marshfield.
Place: Marinette. Time: November 1941.

NEW ENGLAND OPHTHALMOLOGICAL SOCIETY

President: Dr. William D. Rowland, 84 Commonwealth Ave., Boston.
Secretary-Treasurer: Dr. Trygve Gundersen, 243 Charles St., Boston.
Place: Massachusetts Eye and Ear Infirmary, 243 Charles St., Boston. Time: 8 p. m., third Tuesday of each month from November to April, inclusive.

PACIFIC COAST OTO-OPHTHALMOLOGICAL SOCIETY

President: Dr. Isaac H. Jones, 635 S. Westlake Ave., Los Angeles.
Secretary-Treasurer: Dr. C. Allen Dickey, 450 Sutter St., San Francisco.

PUGET SOUND ACADEMY OF OPHTHALMOLOGY AND OTO-LARYNGOLOGY

President: Dr. Spencer S. Howe, 103 E. Holly St., Bellingham, Wash.
Secretary-Treasurer: Dr. Barton E. Peden, 419 Stimson Bldg., Seattle.
Place: Seattle or Tacoma, Wash. Time: Third Tuesday of each month, except June, July and August.

ROCK RIVER VALLEY EYE, EAR, NOSE AND THROAT SOCIETY

President: Dr. W. H. Elmer, 321 W. State St., Rockford, Ill.
Secretary-Treasurer: Dr. Harry R. Warner, 321 W. State St., Rockford, Ill.
Place: Rockford, Ill., or Janesville or Beloit, Wis. Time: Third Tuesday of each month from October to April, inclusive.

SAGINAW VALLEY ACADEMY OF OPHTHALMOLOGY AND OTOLARYNGOLOGY

President: Dr. M. Kessler, 311 Center Ave., Bay City, Mich.
Secretary-Treasurer: Dr. J. H. Curts, 330 S. Washington Ave., Saginaw, Mich.
Place: Saginaw or Bay City, Mich. Time: Second Tuesday of each month, except July and August.

SIOUX VALLEY EYE AND EAR ACADEMY

President: Dr. J. C. Davis, 1615 Howard St., Omaha.
Secretary-Treasurer: Dr. J. E. Dvorak, 408 Davidson Bldg., Sioux Falls, S. D.

SOUTHERN MEDICAL ASSOCIATION, SECTION ON EYE, EAR, NOSE AND THROAT

Chairman: Dr. Grady E. Clay, Medical Arts Bldg., Atlanta, Ga.
Secretary: Dr. John R. Hume, 921 Canal St., New Orleans.

SOUTHWESTERN ACADEMY OF EYE, EAR, NOSE AND THROAT

President: Dr. Franklin P. Maury, Professional Bldg., Tucson, Ariz.
Secretary: Dr. A. E. Cruthirds, 1011 Professional Bldg., Phoenix, Ariz.

SOUTHWESTERN MICHIGAN TRIOLOGICAL SOCIETY

President: Dr. W. M. Dodge, 716 First National Bank Bldg., Battle Creek.
Secretary-Treasurer Dr. Kenneth Lowe, 25 W. Michigan Ave., Battle Creek.
Time: Last Thursday of September, October, November, March, April and May.

WESTERN PENNSYLVANIA EYE, EAR, NOSE AND THROAT SOCIETY

President: Dr. C. H. Bailey, 29 S. Oakland Ave., Sharon.
Secretary-Treasurer: Dr. J. McClure Tyson, Deposit Nat'l Bank Bldg., DuBois.

## STATE

ARKANSAS STATE MEDICAL SOCIETY, EYE, EAR, NOSE AND THROAT SECTION

President: Dr. R. R. Kirkpatrick, 6th and Walnut Sts., Texarkana, Ark.
Secretary-Treasurer: Dr. Raymond C. Cook, 701 Main St., Little Rock.

COLORADO OPHTHALMOLOGICAL SOCIETY

President: Dr. William M. Bane, 1612 Tremont Pl., Denver.
Secretary: Dr. Harry Shankel, Republic Bldg., Denver.
Place: University Club, Denver. Time: 7:30 p. m., third Saturday of each month, October to May, inclusive.

### Connecticut State Medical Society, Section on Eye, Ear, Nose and Throat

President: Dr. Edward N. DeWitt, 836 Myrtle Ave., Bridgeport.
Secretary-Treasurer: Dr. Henry L. Birge, 179 Allyn St., Hartford.

### Eye, Ear, Nose and Throat Club of Georgia

President: Dr. E. N. Maner, 247 Bull St., Savannah.
Secretary-Treasurer: Dr. C. K. McLaughlin, 567 Walnut St., Macon.

### Indiana Academy of Ophthalmology and Oto-Laryngology

President: Dr. F. McK. Ruby, Union City.
Secretary: Dr. Edwin W. Dyar Jr., 23 E. Ohio St., Indianapolis.
Place: French Lick. Time: First Wednesday in April.

### Iowa Academy of Ophthalmology and Oto-Laryngology

President: Dr. J. K. Von Lackum, 117–3d St. S.E., Cedar Rapids.
Secretary-Treasurer: Dr. B. M. Merkel, 604 Locust St., Des Moines.

### Louisiana-Mississippi Ophthalmological and Otolaryngological Society

President: Dr. Henry N. Blum, 912 American Bank Bldg., New Orleans.
Secretary-Treasurer: Dr. Edley H. Jones, 1301 Washington St., Vicksburg, Miss.

### Michigan State Medical Society, Section of Ophthalmology and Otolaryngology

Chairman: Dr. Robert H. Fraser, 25 W. Michigan Ave., Battle Creek.
Secretary: Dr. R. G. Laird, 114 Fulton St., Grand Rapids.

### Minnesota Academy of Ophthalmology and Otolaryngology

President: Dr. Erling Wilhelm Hansen, 78 S. 9th St., Minneapolis.
Secretary-Treasurer: Dr. George E. McGeary, 920 Medical Arts Bldg., Minneapolis.
Time: Second Friday of each month from October to May.

### Montana Academy of Oto-Ophthalmology

President: Dr. A. L. Hammerel, 208 N. Broadway, Billings.
Secretary: Dr. Fritz D. Hurd, 309 Medical Arts Bldg., Great Falls.

### Nebraska Academy of Ophthalmology and Otolaryngology

President: Dr. W. Howard Morrison, 1500 Medical Arts Bldg., Omaha.
Secretary-Treasurer: Dr. John Peterson, 1307 N St., Lincoln.

### New Jersey State Medical Society, Section on Ophthalmology, Otology and Rhinolaryngology

Chairman: Dr. Edgar P. Cardwell, 47 Central Ave., Newark.
Secretary: Dr. Arthur E. Sherman, 243 S. Harrison St., East Orange.

### New York State Medical Society, Eye, Ear, Nose and Throat Section

Chairman: Dr. Searle B. Marlow, 109 S. Warren St., Syracuse.
Secretary: Dr. C. Stewart Nash, 277 Alexander St., Rochester.

### North Carolina Eye, Ear, Nose and Throat Society

President: Dr. M. R. Gibson, Professional Bldg., Raleigh.
Secretary: Dr. Vanderbilt F. Couch, 105 W. 4th St., Winston-Salem.

### North Dakota Academy of Ophthalmology and Oto-Laryngology

President: Dr. A. E. Spear, Dickinson.
Secretary-Treasurer: Dr. F. L. Wicks, 516–6th St., Valley City.

OREGON ACADEMY OF OPHTHALMOLOGY AND OTO-LARYNGOLOGY

President: Dr. Paul Bailey, 833 S. W. 11th Ave., Portland.
Secretary-Treasurer: Dr. R. S. Fixott, 1020 S. W. Taylor St., Portland.
Place: Good Samaritan Hospital, Portland. Time: Third Tuesday of each month.

RHODE ISLAND OPHTHALMOLOGICAL AND OTOLOGICAL SOCIETY

Acting President: Dr. N. Darrell Harvey, 112 Waterman St., Providence.
Secretary-Treasurer: Dr. Linley C. Happ, 124 Waterman St., Providence.
Place: Rhode Island Medical Society Library, Providence. Time: 8:30 p. m., second Thursday in October, December, February and April.

SOUTH CAROLINA SOCIETY OF OPHTHALMOLOGY AND OTOLARYNGOLOGY

President: Dr. Roderick Macdonald, Rock Hill.
Secretary: Dr. J. W. Jervey Jr., 101 Church St., Greenville.
Place: Columbia Hotel, Columbia. Time: November 1941.

TENNESSEE ACADEMY OF OPHTHALMOLOGY AND OTOLARYNGOLOGY

President: Dr. Wesley Wilkerson, 700 Church St., Nashville.
Secretary-Treasurer: Dr. W. D. Stinson, 124 Physicians and Surgeons Bldg., Memphis.

TEXAS OPHTHALMOLOGICAL AND OTO-LARYNGOLOGICAL SOCIETY

President: Dr. E. L. Goar, 1300 Walker Ave., Houston.
Secretary: Dr. Dan Brannin, 929 Medical Arts Bldg., Dallas.
Place: San Antonio. Time: December 1941.

UTAH OPHTHALMOLOGICAL SOCIETY

President: Dr. Rowland H. Merrill, 1010 First National Bank Bldg., Salt Lake City.
Secretary-Treasurer: Dr. Earl H. Phillips, 628 Judge Bldg., Salt Lake City.
Place: University Club, Salt Lake City. Time: 7:00 p. m., third Monday of each month.

VIRGINIA SOCIETY OF OTO-LARYNGOLOGY AND OPHTHALMOLOGY

President: Dr. George G. Hawkins, Newport News.
Secretary-Treasurer: Dr. Guy Fisher, 3 E. Beverley St., Staunton.

WEST VIRGINIA STATE MEDICAL ASSOCIATION, EYE, EAR, NOSE AND THROAT SECTION

President: Dr. George Traugh, 309 Cleveland Ave., Fairmont.
Secretary: Dr. Welch England, 621½ Market St., Parkersburg.

## LOCAL

AKRON ACADEMY OF OPHTHALMOLOGY AND OTOLARYNGOLOGY

President: Dr. George E. Black, 7 W. Bowery St., Akron, Ohio.
Secretary-Treasurer: Dr. C. R. Andersen, 106 S. Main St., Akron, Ohio.
Time: First Monday in January, March, May and November.

ATLANTA EYE, EAR, NOSE AND THROAT SOCIETY

President: Dr. Stacy C. Howell, 144 Ponce de Leon Ave. N. E., Atlanta, Ga.
Secretary: Dr. Lester A. Brown, 478 Peachtree St. N. E., Atlanta, Ga.
Place: Grady Hospital. Time: 6:00 p. m., second Wednesday of each month from October to May.

BALTIMORE MEDICAL SOCIETY, SECTION ON OPHTHALMOLOGY

Chairman: Dr. Ernst Bodenheimer, 1212 Eutaw Pl., Baltimore.
Secretary: Dr. Thomas R. O'Rourk, 104 W. Madison St., Baltimore.
Place: Medical and Chirurgical Faculty, 1211 Cathedral St. Time: 8:30 p. m. fourth Thursday of each month from October to March.

### Birmingham Eye, Ear, Nose and Throat Club

President: Each member, in alphabetical order.
Secretary: Dr. Luther E. Wilson, 919 Woodward Bldg., Birmingham, Ala.
Place: Tutwiler Hotel. Time: 6:30 p. m., second Tuesday of each month, September to May, inclusive.

### Brooklyn Ophthalmological Society

President: Dr. Maurice Wieselthier, 1322 Union St., Brooklyn.
Secretary-Treasurer: Dr. Harold F. Schilback, 142 Joralemon St., Brooklyn.
Place: Kings County Medical Society Bldg., 1313 Bedford Ave. Time: Third Thursday in February, April, May, October and December.

### Buffalo Ophthalmologic Club

President: Dr. Meyer H. Riwchun, 367 Linwood Ave., Buffalo.
Secretary-Treasurer: Dr. Sheldon B. Freeman, 196 Linwood Ave., Buffalo.
Time: Second Thursday of each month.

### Chattanooga Society of Ophthalmology and Otolaryngology

President: Each member, in alphabetical order.
Secretary: Dr. Douglas Chamberlain, Chattanooga Bank Bldg., Chattanooga, Tenn.
Place: Mountain City Club. Time: Second Thursday of each month from September to May.

### Chicago Ophthalmological Society

President: Dr. Sanford Gifford, 720 N. Michigan Ave., Chicago.
Secretary-Treasurer: Dr. Vernon M. Leech, 55 E. Washington St., Chicago.
Place: Chicago Towers Club, 505 N. Michigan Ave. Time: Third Monday of each month from October to May.

### Cincinnati General Hospital Ophthalmology Staff

Chairman: Dr. D. T. Vail, 441 Vine St., Cincinnati.
Secretary: Dr. A. A. Levin, 441 Vine St., Cincinnati.
Place: Cincinnati General Hospital. Time: 7:45 p. m., third Friday of each month except June, July and August.

### Cleveland Ophthalmological Club

Chairman: Dr. W. J. Abbott, 10515 Carnegie Ave., Cleveland.
Secretary: Dr. L. V. Johnson, 2065 Adelbert Rd., Cleveland.
Time: Second Tuesday in October, December, February and April.

### College of Physicians, Philadelphia, Section on Ophthalmology

Chairman: Dr. Francis H. Adler, 313 S. 17th St., Philadelphia.
Clerk: Dr. W. S. Reese, 1901 Walnut St., Philadelphia.
Time: Third Thursday of every month from October to April, inclusive.

### Columbus Ophthalmological and Oto-Laryngological Society

Chairman: Dr. C. D. Postle, 240 E. State St., Columbus, Ohio.
Secretary-Treasurer: Dr. Hugh C. Thompson, 289 E. State St., Columbus, Ohio.
Place: The Neil House. Time: 6 p. m., first Monday of each month.

### Corpus Christi Eye, Ear, Nose and Throat Society

Chairman: Dr. F. K. Stroud, 416 Chaparral St., Corpus Christi, Texas.
Secretary: Dr. Arthur Padilla, 414 Medical Professional Bldg., Corpus Christi, Texas.
Time: Second Friday of each month from October to May.

### Dallas Academy of Ophthalmology and Oto-Laryngology

President: Dr. L. A. Nelson, 4105 Live Oak St., Dallas, Texas.
Secretary: Dr. S. F. Harrington, 921 Medical Arts Bldg., Dallas, Texas.
Place: Dallas Athletic Club. Time: 6:30 p. m., first Tuesday of each month from October to June. The November, January and March meetings are devoted to clinical work.

### Des Moines Academy of Ophthalmology and Otolaryngology

President: Dr. H. C. Schmitz, 604 Locust St., Des Moines, Iowa.
Secretary-Treasurer: Dr. Byron M. Merkel, 604 Locust St., Des Moines, Iowa.
Time: 7:45 p. m., third Monday of every month from September to May.

### Detroit Ophthalmological Club

Chairman: Members rotate alphabetically.
Secretary: Dr. Harvey E. Dowling, 2414 Eaton Tower, Detroit.
Time: 6:30 p. m., first Wednesday of each month.

### Detroit Ophthalmological Society

President: Dr. Parker Heath, 1553 Woodward Ave., Detroit.
Secretary: Dr. Leland F. Carter, 1553 Woodward Ave., Detroit.
Place: Club rooms of Wayne County Medical Society. Time: Third Thursday of each month from November to April, inclusive.

### Eastern New York Eye, Ear, Nose and Throat Association

President: Dr. L. A. Hulsebosch, 191 Glen St., Glen Falls.
Secretary-Treasurer: Dr. Joseph L. Holohan, 330 State St., Albany.
Time: Third Wednesday in October, November, March, April, May and June.

### Fort Worth Eye, Ear, Nose and Throat Society

President: Dr. W. R. Thompson, 602 W. 10th St., Fort Worth, Texas.
Secretary-Treasurer: Dr. A. E. Jackson, 602 W. 10th St., Fort Worth, Texas.
Place: Medical Hall, Medical Arts Bldg. Time: 7:30 p. m., first Friday of each month except July and August.

### Houston Academy of Medicine, Ophthalmological and Oto-Laryngological Section

President: Dr. Wallace W. Ralston, 1304 Walker Ave., Houston, Texas.
Secretary: Dr. William J. Snow, 708 Medical Arts Bldg., Houston, Texas.
Place: Medical Arts Bldg., Harris County Medical Society Rooms. Time: 8 p. m., second Thursday of each month from September to June.

### Indianapolis Ophthalmological and Otolaryngological Society

President: Dr. John I. Garret, 57 Stokes Bldg., Indianapolis.
Secretary: Dr. Kenneth L. Craft, 23 E. Ohio St., Indianapolis.
Place: Indianapolis Athletic Club. Time: 6:30 p. m., second Thursday of each month from November to May.

### Kansas City Society of Ophthalmology and Oto-Laryngology

President: Dr. Homer Beal, 1103 Grand Ave., Kansas City, Mo.
Secretary: Dr. Desmond Curran, Federal Reserve Bank Bldg., Kansas City, Mo.
Time: Third Thursday of each month from October to June. The November, January and March meetings are devoted to clinical work.

### Long Beach Eye, Ear, Nose and Throat Society

Chairman: Dr. Harold Snow, 614 S. Pacific Ave., San Pedro, Calif.
Secretary-Treasurer: Dr. Oliver R. Nees, 508 Times Bldg., Long Beach, Calif.
Place: Professional Bldg. Time: Last Wednesday of each month from October to May.

### Los Angeles Society of Ophthalmology and Otolaryngology

President: Dr. Harold Mulligan, 1680 N. Vine St., Los Angeles.
Secretary-Treasurer: Dr. Colby Hall, 1136 W. 6th St., Los Angeles.
Place: Los Angeles County Medical Association Bldg., 1925 Wilshire Blvd. Time: 6:00 p. m., fourth Monday of each month from September to May, inclusive.

### Louisville Eye and Ear Society

President: Dr. Joseph S. Heitger, Heyburn Bldg., Louisville, Ky.
Secretary-Treasurer: Dr. J. W. Fish, 321 W. Broadway, Louisville, Ky.
Place: Brown Hotel. Time: 6:30 p. m., second Thursday of each month from September to May, inclusive.

### Medical Society of the District of Columbia, Section of Ophthalmology and Otolaryngology

Chairman: Dr. E. J. Cummings, 1835 I St. N. W., Washington.
Secretary: Dr. P. S. Constantinople, 1835 I St. N. W., Washington.
Place: 1718 M St. N. W. Time: 8 p. m., third Friday of each month from October to April, inclusive.

### Memphis Society of Ophthalmology and Otolaryngology

Chairman: Each member, in alphabetical order.
Secretary: Dr. Sam H. Sanders, 1089 Madison Ave., Memphis, Tenn.
Place: Eye Clinic of Memphis Eye, Ear, Nose and Throat Hospital. Time: 8 p. m., second Tuesday of each month from September to May.

### Milwaukee Oto-Ophthalmic Society

President: Dr. John B. Hitz, 411 E. Mason St., Milwaukee.
Secretary-Treasurer: Dr. Ralph T. Rank, 238 W. Wisconsin Ave., Milwaukee.
Place: University Club. Time: 6:30 p. m., second Tuesday of each month.

### Montgomery County Medical Society

Chairman: Dr. H. V. Dutrow, 1040 Fidelity Medical Bldg., Dayton, Ohio.
Secretary-Treasurer: Dr. Maitland D. Place, 981 Reibold Bldg., Dayton, Ohio.
Place: Van Cleve Hotel. Time: 6:30 p. m., first Tuesday of each month from October to June, inclusive.

### Montreal Ophthalmological Society

President: Dr. J. Rosenbaum, 1396 Ste. Catherine St. W., Montreal, Canada.
Secretary: Dr. L. Tessier, 1230 St. Joseph Blvd. E., Montreal, Canada.
Time: Second Thursday of October, December, February and April.

### Nashville Academy of Ophthalmology and Otolaryngology

Chairman: Dr. Andrew Hollabaugh, Doctors Bldg., Nashville, Tenn.
Secretary: Dr. Guy Maness, Medical Arts Bldg., Nashville, Tenn.
Place: St. Thomas Hospital. Time: 8 p. m., third Monday of each month from October to May.

### New Haven Ophthalmological Society

President: Dr. William H. Ryder, 185 Church St., New Haven, Conn.
Secretary: Dr. Frederick A. Wies, 255 Bradley St., New Haven, Conn.

### New Orleans Ophthalmological and Otolaryngological Society

President: Dr. W. B. Clark, 1012 American Bank Bldg., New Orleans.
Secretary: Dr. Mercer G. Lynch, 1018 Maison Blanche Bldg., New Orleans.
Place: Louisiana State University Medical Bldg. Time: 8 p. m., second Tuesday of each month from October to May.

### New York Academy of Medicine, Section of Ophthalmology

Chairman: Dr. Algernon Reese, 73 E. 71st St., New York.
Secretary: Dr. Brittain Payne, 896 Madison Ave., New York.
Time: 8:30 p. m., third Monday of every month from October to May, inclusive.

### New York Society for Clinical Ophthalmology

President: Dr. James W. Smith, 1016–5th Ave., New York.
Secretary: Dr. Benjamin Esterman, 983 Park Ave., New York.
Place: Squibb Hall, 745–5th Ave. Time: 8 p. m., first Monday of each month from October to May, inclusive.

### Oklahoma City Academy of Ophthalmology and Otolaryngology

President: Dr. R. E. Leatherock, Cushing, Okla.
Secretary: Dr. Harry C. Ford, 1014 Medical Arts Bldg., Oklahoma City.
Place: University Hospital. Time: Second Tuesday of each month from September to May.

### Omaha and Council Bluffs Ophthalmological and Oto-Laryngological Society

President: Dr. Harold Gifford, 1620 Medical Arts Bldg., Omaha.
Secretary-Treasurer: Dr. W. Howard Morrison, 1500 Medical Arts Bldg., Omaha.
Place: Omaha Club, 20th and Douglas Sts., Omaha. Time: 6 p. m., dinner; 7 p. m., program; third Wednesday of each month from October to May.

### Passaic-Bergen Ophthalmological Club

President: Dr. L. Markowitz, 16 Church St., Paterson, N. J.
Secretary-Treasurer: Dr. A. John Reinhorn, 302 Broadway, Paterson, N. J.
Place: Paterson Eye and Ear Infirmary. Time: 9 p. m., last Friday of every month, except June, July and August.

### Philadelphia County Medical Society, Eye Section

Chairman: Dr. Edmund B. Spaeth, 1930 Chestnut St., Philadelphia.
Secretary: Dr. Wilfred E. Fry, 1819 Chestnut St., Philadelphia.
Time: First Thursday of each month from October to May.

### Pittsburgh Ophthalmological Society

President: Dr. J. Clyde Markel, 200–9th St., Pittsburgh.
Secretary: Dr. George H. Shuman, 351–5th Ave., Pittsburgh.
Place: Pittsburgh Academy of Medicine Bldg. Time: Fourth Monday of each month, except June, July, August and September.

### Richmond Ophthalmological and Oto-Laryngological Society

President: Dr. W. F. Bryce, Medical Arts Bldg., Richmond, Va.
Secretary: Dr. Richard W. Vaughan, Medical Arts Bldg., Richmond, Va.
Place: Westmoreland Club. Time: 6 p. m., second Monday of each month from October to May.

### Rochester Eye, Ear, Nose and Throat Society

President: Dr. E. J. Avery, 11 N. Goodman St., Rochester, N. Y.
Secretary-Treasurer: Dr. Charles T. Sullivan, 277 Alexander St., Rochester, N. Y.

### St. Louis Ophthalmic Society

President: Dr. William M. James, 508 N. Grand Blvd., St. Louis.
Secretary: Dr. H. Rommel Hildreth, 823 Metropolitan Bldg., St. Louis.
Place: Oscar Johnson Institute. Time: Clinical meeting 5:30 p. m., dinner and scientific meeting 6:30 p. m., fourth Friday of each month from October to April, inclusive, except December.

### San Antonio Ophthalmolo-Oto-Laryngological Society

President: Dr. Dan Russell, 705 E. Houston St., San Antonio, Texas.
Secretary-Treasurer: Dr. P. G. Bowen, 315 Camden St., San Antonio, Texas.
Place: Bexar County Medical Library. Time: 8 p. m., first Tuesday of each month from October to May.

### San Francisco County Medical Society, Section on Eye, Ear, Nose and Throat

Chairman: Dr. Fred Boyle, 490 Post St., San Francisco.
Secretary: Dr. Frank Hand, 450 Sutter St., San Francisco.
Place: Society's Bldg., 2180 Washington St., San Francisco. Time: Fourth Tuesday of every month except June, July and December.

### Shreveport Eye, Ear, Nose and Throat Society

President: Dr. David C. Swearingen, Slattery Bldg., Shreveport, La.
Secretary-Treasurer: Dr. Kenneth Jones, Medical Arts Bldg., Shreveport, La.
Place: Shreveport Charity Hospital. Time: 7:30 p. m., first Monday of every month except July, August and September.

### Spokane Academy of Ophthalmology and Oto-Laryngology

President: Dr. Louis A. Parsell, 407 Riverside Ave., Spokane, Wash.
Secretary: Dr. Robert L. Pohl, 407 Riverside Ave., Spokane, Wash.
Place: Paulsen Medical and Dental Library. Time: 8 p. m., fourth Tuesday of each month except June, July and August.

### Syracuse Eye, Ear, Nose and Throat Society

President: Dr. F. R. Webster, State Tower Bldg., Syracuse, N. Y.
Secretary-Treasurer: Dr. John R. Myers, State Tower Bldg., Syracuse, N. Y.
Place: University Club. Time: First Tuesday of each month except June, July and August.

### Toledo Eye, Ear, Nose and Throat Society

Chairman: Dr. J. E. Minns, 316 Michigan St., Toledo, Ohio.
Secretary: Dr. John D. Skow, 2001 Collingwood Blvd., Toledo, Ohio.
Place: Toledo Club. Time: Each month except June, July and August.

### Toronto Academy of Medicine, Section of Ophthalmology

Chairman: Dr. W. R. F. Luke, 316 Medical Arts Bldg., Toronto, Canada.
Secretary: Dr. W. T. Gratton, 216 Medical Arts Bldg., Toronto, Canada.
Place: Academy of Medicine, 13 Queens Park. Time: First Monday of each month, November to April.

### Washington, D. C., Ophthalmological Society

President: Dr. E. Leonard Goodman, 1801 I St. N. W., Washington, D. C.
Secretary-Treasurer: Dr. Sterling Bockoven, 1752 Massachusetts Ave. N.W., Washington, D. C.
Place: Episcopal Eye, Ear and Throat Hospital. Time: 7:30 p. m., first Monday in November, January, March and April.

### Wilkes-Barre Ophthalmological Society

Chairman: Each member in turn.
Secretary: Dr. Samuel T. Buckman, 70 S. Franklin St., Wilkes-Barre, Pa.
Place: Office of chairman. Time: Last Tuesday of each month from October to May.